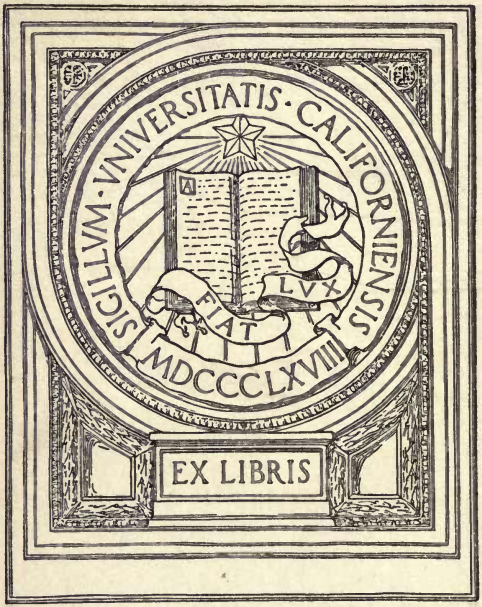
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HANDBOOK OF MOSSES,

WITH AN ACCOUNT OF THEIR

STRUCTURE, CLASSIFICATION, GEOGRAPHICAL DISTRIBUTION, AND HABITATS.

BY

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London:

SWAN SONNENSCHEIN, LE BAS & LOWREY,

PATERNOSTER SQUARE.

1886.

Butler & Tanner,
The Selwood Printing Works,
Frome, and London.

PREFACE.

THIS little Essay has been written in the leisure hours of one whose every-day life is spent amid the busy hum and constant strain of a work-a-day life in a large town, with the hope that he may call the attention of others similarly situated to himself to the beauties and wonders of some of God's fairest works. The study has been to him one of constant enjoyment, has led him into many a charming spot, has given him many a much-prized friendship, has informed his mind, gladdened his heart, and gratified his eyes; and he would say to any one who is in search of objects of real interest: Study the Mosses. No objects are more readily found, for everywhere in nature you will find the Mosses. And if you desire a study which will present you with a constant supply of interesting objects—whether you take the varieties of leaf form, or notice the elegant designs of the little capsules, or study the exquisite beauty of those minute fringes which adorn the capsules of so many of our mosses, passing by degrees most gradual from the simplest to the most complicated structures, or study that most elementary of all organisms, the vegetable cell, and observe how by

this simple organism all the thousand species and varieties of moss are built up, all diversified, and yet all alike mere cellular structures—if you desire a study which will find you employment, interesting and fascinating employment for your leisure hours the whole year round, and which, if pursued aright, will never grow wearisome, let me advise you to study the Mosses. To quote the glowing words of Ruskin, "No words that I know of will say what these Mosses are, none are delicate enough, none perfect enough, none rich enough."

In compiling these notes I have availed myself of Wilson's very excellent "Bryologia Britannica," Berkeley's "Handbook of British Mosses," Schimper's "Synopsis Muscorum Europæorum," Berkeley's "Cryptogamic Botany," Braithwaite's "Sphagnaceæ of Europe and North America," and also a very able paper by Dr. Braithwaite "On the Geographical Distribution of Mosses in Europe."

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HANDBOOK OF MOSSES.

INTRODUCTION.

Meek creatures! the first mercy of the earth, visiting with hushed softness its dintless rocks; creatures full of pity, covering with strange and tender honour the scarred disgrace of ruin—laying quiet finger on the trembling stones to teach them rest. No words, that I know of, will say what these mosses are. None are delicate enough, none perfect enough, none rich enough. How is one to tell of the rounded bosses of furred and beaming green,—the starred divisions of rubied bloom, fine-filmed, as if the rock spirits could spin porphyry as we do glass,—the traceries of intricate silver, and fringes of amber, lustrous, arborescent, burnished through every fibre into fitful brightness and glossy traverses of silken change, yet all subdued and pensive, and framed for simplest, sweetest offices of grace? They will not be gathered, like the flowers, for chaplet or love-token; but of these the wild bird will make its nest, and the wearied child his pillow.

And, as the earth's first mercy, so they are its last gift to us: when all other service is vain from plant and tree, the soft mosses and grey lichen take up their watch by the head-stone. The woods, the blossoms, the gift-bearing grasses, have done their parts for a time; but these do service for ever. Trees for the builder's yard, flowers for the bride's chamber, corn for the granary, moss for the grave.

Ruskin's "Modern Painters," vol. v., pp. 102, 103.

A WALK through green fields, country lanes, or woods is rendered more enjoyable, and I believe more conducive to healthy exercise, if we have some special study to call us there, than such a walk would be if indulged in for the mere sake of what is termed a constitutional. For it is well to have something that will for a time enable us to for-

get the every-day cares of a busy life; and nothing is so likely to do this as some pursuit that not only engrosses the attention, but also gladdens the eye, that calls forth healthy thought, educates the observing faculties, and stimulates us to take a certain amount of invigorating exercise. To any person with ordinary enthusiasm, interest, and industry, the study of the mosses will yield all this and more.

Too frequently these plants are neglected by even professed botanists. The investigation of them is considered to be too difficult, or too tedious, and often too expensive. That there are difficulties connected with the study all must admit, but none that a little patience and industry will not surmount; the tedium of the study would evaporate after the first few hours' examination of these beautiful organisms, and the expense after the first outlay need not be more than a little extra wear and tear of one's shoe leather.

To say that the study of these plants is interesting would be trite, for everything in beautiful nature is interesting, but the "dim world of weeping mosses" is wondrously interesting; so varied in structure, in form, in mode of growth, in colour, covering the bosom of their mother earth with a green, velvety mantle when the cold winds of autumn and winter have robbed the trees of their beautiful foliage, and the nipping frosts have chilled into death their lovely sisters, the flowering plants, clothing with beauty the wayside bank, clinging with a tender embrace to their high-born kinsman the forest tree, bedecking with a thousand fairy urns the old ruined wall, covering with beautifully mingled masses of feathery *Hypnum*, tufted *Bryum*, or hoary *Tortula*, of every shade of green, the rotting thatch of the ruined cottage, filling the treacherous bog with pale green *Sphagnum* or beautiful tussocks of noble looking *Polytrichum*, flourishing amid the unpleasant odours of the poison-breathing marsh, and climbing slowly but surely from the lowest valley to the snow line of the great mountain!

And were we to follow them in their daring scramble, and note them well, we should see that the mosses are, not only countless in numbers, but multitudinous in varieties

and species; the moss flora of our own islands alone numbering about 140 genera and nearly 600 species, besides varieties without end. A superficial observer would probably be astonished if he were to have pointed out to him the varied species to be found upon a few square feet of a bank "with bright green mosses clad," because to him a moss is a moss and nothing more; and yet in such a limited area twenty or more species may often be found; and many a district that at first sight seems able to yield but a poor moss flora may by a little diligence be proved to be quite prolific. A limited district of some 3,500 acres has yielded the writer nearly 130 species of these plants, all of them beautiful and some of them very rare.

Then it must be remembered that mosses are easily preserved, usually retain their special characters even when dried, may be prepared for the herbarium, and packed in comparatively small compass, and may be examined at any time; for, however shrivelled they may have become by long keeping, a few minutes' soaking in tepid water will restore them to most of their former beauty, their lovely leaves again expand, the minute cells of which they are built are again filled with fluids, and with the aid of the microscope all their details may be made out as readily as though they had been gathered but an hour ago, so that for real and minute study this may truly be called a fireside one.

For the sake of those who would wish to commence the study, but lack the knowledge how to begin, when and where to seek their plants, and how to distinguish them when found, these hints have been written, and I shall endeavour, as clearly as I can, to supply a few elementary lessons in moss collecting, etc.

I.

APPLIANCES AND MATERIAL REQUIRED FOR THE STUDY.

BEFORE beginning to collect, certain aids are required: these are few and simple. First, a bag or satchel of some kind for stowing away specimens as they are gathered. One of the canvas bags with a strap to sling over the shoulder, such as are now offered from a shilling upwards, will be serviceable and sufficient. Some pieces of good strong newspaper six to nine inches square will be required to wrap up each specimen separately as gathered. These papers should be numbered previous to starting out, using ink rather than pencil, for the mosses will often be wet, and pencil marks are then easily obliterated. In order to keep the tufts of moss clean and distinct too many should not be put into one paper. When the paper is filled and folded, the number of the package should be entered in the collector's notebook, with remarks as to habitat, locality, and date. Such, for instance, as this: "No. 1. Marly bank, Tythall Lane, near Solihull. Formation, keuper marl. Feb. 9th, 1878." And such other particulars as it may be well to remember.

And here I may observe that at first it would be advisable to collect those mosses only which have their fruit fully matured, and then, when these have been carefully examined and their distinguishing characters mastered, barren specimens may be collected; for many of our rarest British mosses are more frequently found barren than fruiting, and they must not, of course, be neglected. As soon as home is reached, each of the packages should be opened, and, if time serves, roughly examined. If not, they should be placed in the opened papers on the floor of a room where they will be undisturbed, and allowed to get

thoroughly dry. It will be advisable at the same time to place a slip of paper with each package containing a copy of the notes from notebook. When the specimens are dry they may be again wrapped up, and put by for an indefinite time for future examination. If the mosses are allowed to dry in the unopened papers just as they are gathered they will be nearly certain to become mildewed, and will be very unsightly and useless, and thus the trouble of collecting will have been taken in vain.

All these details may seem to make the preliminary work very tedious to the beginner, but he will soon get over any irksomeness he may at first feel, and he will be rewarded by his specimens being saved in good condition.

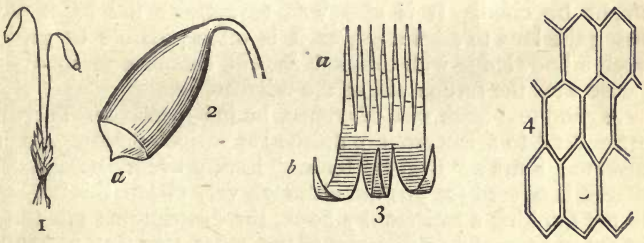

FIG. 1. *Bryum cæspiticium.* 1, plant natural size. 2, pendulous capsule; *a*, mammilatelid. 3, peristome; *a*, inner membrane; *b*, outer teeth. 4, areolation of leaf

A pocket lens will be required for the examination of the plants in the field, one having a power of about ten diameters, *i.e.* about one inch focal length, will be found serviceable, and if with two powers, *i.e.* a one inch and a half inch focal length, still more so. These lenses, in horn and other fittings, may be obtained from all opticians, at 1*s.* upwards, the price varying according to the finish of the article. If the School Microscope (mentioned p. 8) is obtained, one or more of the lenses supplied with it may be made to do service in the field; but if so used, they should always be carried in a small chamois leather bag to protect from scratches. It is better however not to use them for this purpose.

It is advisable to acquire the habit of noticing all the features of the mosses with the unassisted eye. The constant use of a lens is trying to the eyes, and I believe often materially injures them. Most of the ordinary details may be thus observed, such as the position of the leaves on the stem, general characters, etc., noticing whether they are erect, spreading, curved, or falcate, and so on, and their direction when in the dry state. This latter character is often a ready guide to nearly allied species. For instance, two mosses common on wall tops, *Bryum capillare* and *B. cæspiticium* (fig. 1), both having many features in common when moist, differ materially in appearance when dry, the former having the leaves remarkably twisted, the latter straight and imbricated. Many other like instances might be cited. It is also well to acquire the habit of using the lens to advantage, as it is often possible to gain such a knowledge with this aid as will enable one to dispense with the further aid of the microscope.

A good text-book will, of course, be indispensable. There are several to select from, published at various prices. For instance, Stark's "British Mosses," having twenty coloured plates, is offered for 5*s.*; but although very cheap, this is not to my thinking a satisfactory book, the descriptions are too vague to be useful; still many of the more frequent mosses may be made out by its aid. Berkeley's "Handbook of British Mosses," with twenty-four coloured plates, costs 21*s.* new, but may frequently be obtained second-hand for about 14*s.* This is a valuable work, and contains, in addition to the descriptive text, much matter of interest and value. Its greatest fault is, that the nomenclature is not in all cases that most generally adopted, and that the author gives us no synonyms. This, I think, is a serious fault, as it often leaves a tyro in uncertainty as to the name adopted by other authors. As a field book, and also of greatest value in the study, no English work I am acquainted with equals Hobkirk's "Synopsis of the British Mosses," published at 7*s.* 6*d.*, for cheapness and for correctness; its only fault is the absence of plates, which cannot, of course, be expected in so cheap a book. A new edition of this work

has recently appeared, and in this we have all the newest discoveries duly recorded and described; the size is very convenient for the pocket. Wilson's "Bryologia Britannica" is invaluable; but as it is out of print it can only be met with rarely in second-hand book catalogues, and the price ranges from three to six guineas, according to the condition of the book. In this the descriptions are excellent, being those of one of the most able bryologists this country has produced. Besides excellent descriptions, there are also figures of every moss described, and the later plates are very good. This work, having been published in 1855, is quite behind the time in some respects; but a student who makes good use of this work will find that many of the difficulties surrounding the subject will be dispelled. Another very valuable work is Schimper's "Synopsis Muscorum Europæorum"; costs 28*s*., and contains descriptions of all the European species. In the second edition, published 1876, we have a fairly complete record of bryological discoveries so far as Europe is concerned. The work is entirely in Latin, and there are eight plates illustrative of the various genera. The descriptions are very ample, and the notes on the comparative characters of the various species remarkably useful.

Lesquereux and James' "Manual of American Mosses" will also be found of great assistance to British students, as it contains descriptions of at least two-thirds of our native mosses; this costs 24*s*. But the most beautiful and valuable work is the "British Moss Flora," by Dr. R. Braithwaite; in this the various species are graphically described and illustrated, the illustrations being those of a master's hand. The work is being issued in parts, and when finished will be one of the best that has yet appeared.

Every moss student requires a microscope, and, when possible, it is well to have a really good one. These instruments vary in price, a first-class microscope being an expensive luxury; but there are some very good instruments to be obtained at most moderate prices. A great amount of good work may be done with even a cheap microscope; in fact, much of the best work that has been

done for science has been done with comparatively inexpensive instruments.

The most useful cheap instrument I know, is Field's School Microscope, a very compact little instrument, having three simple lenses, which, separate or combined, give a magnifying power of from five to forty diameters. This, with the simple lenses, live box, needle, and other appliances, costs 10*s.* 6*d.*; a compound body may be added for 2*s.* 6*d.* extra. This will give powers of from twenty to eighty diameters. It is well to have this compound body at first, as the cabinet is then made of sufficient size to hold the compound body and all the other apparatus. For an additional 2*s.* 6*d.* a Wollaston doublet may be added; and, as this lens is a combination of plano-convex lenses placed in such a manner and of such a focus as to reduce chromatic and spherical aberrations, for 15*s.* 6*d.*, it is possible to possess a microscope nearly achromatic, giving a power of 120 diameters, which is sufficient for almost all the work which the young botanist will have to do. All my own earliest work in mosses was done with this instrument, and I believe I learned more by its aid than I have ever done with the more expensive instruments I have since used. As a simple microscope it will always be useful for dissecting and mounting purposes, and I can say with confidence, that the student who has acquired all the knowledge of structure that this cheap little instrument will place within his reach will have gained such an insight into the moss world as will enable him to determine with a little patience the most difficult of mosses.

ON THE STUDY OF THE MOSSES.

II.

DEVELOPMENT.

In the last chapter the material and apparatus required for the collecting and study of these plants were treated of. In the present I purpose giving some account of the development of mosses.

Mosses are cellular plants, having distinct stems, leaves, and roots (the Sphagnums, or bog-mosses, are exceptional, as they do not possess roots); they have a capsular fruit, and are developed from spores (*seedlike contents of ripe capsule*, fig. 2, 1), or gemmæ (*cellular bodies capable of becoming plants* fig. 2 *d*).

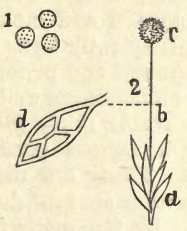

FIG. 2. 1, spores of moss. 2, gemmiform state of Aulacomnion androgynum; *a*, stem; *b*, stalk; *c*, gemmæ. 2 *d*, one of the gemmæ detatched and magnified.

The spores are minute, round, cellular bodies, varying in size, colour, and external marking, and are composed of

two membranes or coats, an inner and an outer one, inclosing a thickened granular mass. Though similar in function to the seeds of flowering plants, they differ from those organs, in being capable of germinating from any part of their surface, and in possessing no embryo (*the young plant contained in the seed*); hence plants developed from spores are termed Acotyledons (Gr. *a*, without, and *kotuledon*, a seed-lobe). The spores which are formed in the capsule are the bodies from which the moss-plant is normally developed.

But many even of our common mosses rarely produce their fruit, and are perpetuated in other ways; as, for instance, by gemmæ, which may be seen forming little globular heads (2 *c*) on the top of a pale, naked stalk (2 *b*) in *Aulacomnion androgynum* (2), so frequent on wayside banks; or from thread-like cellular bodies, abundant on the leaves of some mosses, *Orthotrichum Lyellii*, for instance, frequent on poplars, elms, etc.; or from bud-like bodies formed in the axils of the leaves, as in *Bryum annotinum*, found on sandy banks; or even detached leaves may give origin to a new plant, as in *Campylopus pyriformis*, frequent on heath lands.

When the spores germinate, they give rise to a green, thread-like body, called the protonema (fig. 3 *b*), which is formed by the protrusion of the inner membrane of the spore through the outer one. This, by frequent cell-division, becomes elongated and branched. The primary branch, at first green, frequently turns brown, and, in some cases, penetrates the ground and performs the function of a root. The secondary branches are well charged with chlorophyll (*green, granular matter in the interior of the cell*), and branch frequently. On various parts of the protonema bud-like bodies arise. These are the rudimentary moss-plant. From the buds roots are sent down into the medium on which they grow. By frequently repeated cell-division these buds develop into the leafy moss-stem. Mosses, like ferns, horsetails, etc., grow at the apex only, and are hence termed Acrogens (*plants which increase at the summit only*).

The protonema, which looks very like masses of green

conferva, may be seen forming a velvety mass on the ground in the neighbourhood of mosses; and if a portion of such masses is examined with the microscope, all the stages of growth may frequently be seen. In most mosses the protonema is short-lived, perishing before the moss-plant is fully grown; but in some of the lower forms, as in *Phascum serratum* (fig. 3), it lasts throughout the plant's lifetime. This moss may be found in fallow fields in autumn and spring. The gemmæ before mentioned germinate much in the same way as the spores, forming first the thread-like protonema, upon which the leafy stem is developed.

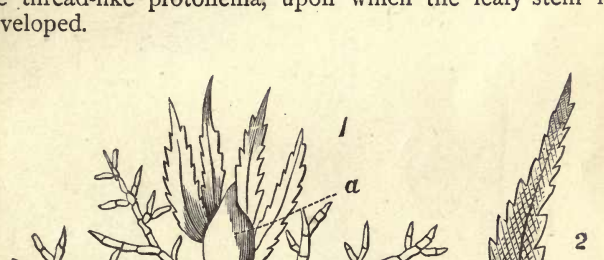

FIG. 3. *Phascum* (*Ephemerum*) *serratum*. 1, plant enlarged; 1 *a*, capsule: 1 *b* protonema. 2, leaf enlarged, showing loose cellular tissue (areolation).

The stem varies in length considerably; in some mosses it is imperceptible without a lens, as in *Phascum serratum*, but in many others it is very apparent. It may be erect, as in *Polytrichum;* or prostrate, as in some of the *Hypnums*, or feather-mosses; simple, as in *Pottia* (fig. 4); or branched, as in *Hypnum* (fig. 5). In some of the terminal-fruited mosses it branches by what are termed innovations; these are extensions of the stem, often arising at the top of the old stem, and such branching is usually forked, each fork representing a year's growth. This mode of branching may be seen in many *Bryums* and other mosses; a convenient

example occurs in *Grimmia pulvinata* (fig. 19), the little hoary, cushion-like patches of which may be seen on wall-tops and thatch.

The stem and branches are more or less densely clothed with leaves, which are always simple (undivided), and vary in shape from awl-shaped to round, the most frequent forms being lance-shaped, or oval. The leaves vary in structure, but are usually formed of a single layer of cells; exceptions occur, as in *Leucobryum;* in this case the leaves are formed of three layers of cells.

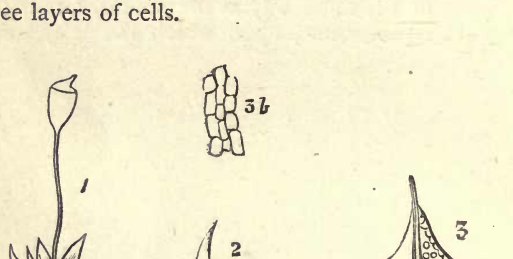

FIG. 4. *Pottia truncata.* 1, plant slightly enlarged. 2, obliquely rostrate operculum; *a*, columella, which remains attached to lid, and falls away with it. 3, tip of leaf; *a*, upper leaf cells; 3 *b*, cells of base of leaf.

The cells forming the leaf assume a variety of forms, but may be referred to two types—I. Parenchymatous (*having the cells placed end to end*), as in *Pottia*, etc. (fig. 4, 3 *b*); II. Prosenchymatous (*having cells which overlap one another at their ends*); these have pointed ends, and are longer than broad, as in *Hypnum* (fig. 5, 4 *a*, and fig. 1, 4). The study of these leaf-cells is one of great importance, as the generic and specific differences of many mosses are often made out by the character of the cells forming the leaf. Among other forms assumed by cells we have round (fig. 34, 4 *a*), as in *Orthotrichum;* quadrate, as in *Pottia* (fig. 4, 3 *b*); hexagonal, as in *Tetraphis;* oblong, as in *Isothecium;* rhomboid, as in

Bryum (fig. 1, 4), etc. The cells at the base of the leaf are frequently of different form from those of the upper part of the leaf, and are often colourless and transparent.

The centre of the leaf is often occupied by elongated

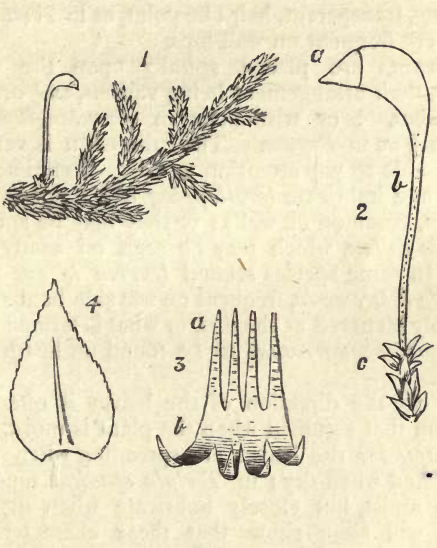

FIG. 5. *Hypnum rutabulum*. 1, a plant natural size, showing pleurocarpous inflorescence. 2, fruit magnified, showing 2 *a*, conical operculum; 2 *b*, rough seta, or fruit-stalk; 2 *c*, recurved perichætial leaves. 3, fringe, or peristome; *a*, inner peristome; *b*, outer peristome. 4, stem leaf; 4 *a*, cells of leaf highly magnified.

cells, forming what is called the nerve or midrib (fig. 5, 4). This nerve is usually simple, but may be forked, as in *Isothecium myurum;* or there may be two nerves, as in *Hypnum triquetrum*, common on marly banks; or the leaves

may be nerveless, as in *Hypnum stellatum*. The nerve is of variable length, in some cases vanishing below the tip of the leaf, in others projecting beyond the tip and forming a short point or mucro, as in *Tortula marginata;* or it may form a long, transparent, hair-like point, as in *Tortula muralis*, a moss very frequent on wall-tops.

The leaves are placed spirally upon the stem and branches, their arrangement being various, as $\frac{1}{2}$ or distichous in *Fissidens*, $\frac{1}{3}$ or tristichous in *Anœctangium*, $\frac{2}{5}$ths in *Pottia*, or $\frac{5}{8}$ as in *Bryum*. Their direction is variable, and it is advisable to pay attention to this. Sometimes they are crowded and imbricate (*overlapping like tiles*), as in *Bryum argenteum*, common on walls; or they may be spreading, as in *Tortula fallax*, which may be seen on sandy or clayey banks. In some species secund (*curved to one side*), as in *Dicranella heteromalla*, frequent on wayside banks; in others remarkably recurved at the tips, or what is termed squarrose, as in *Hypnum squarrosum*, to be found on heath lands and in woods.

When dry the direction of the leaves is often very different from that assumed when the plant is moist. Thus in *Bryum capillare* the leaves are spreading when moist, but much twisted when dry; in *Tortula spadicea* much spreading when moist, but closely imbricate when dry: but experience will soon show that these characters vary in different species of moss. The margin of the leaf (fig. 5, 4) is sometimes plane, at others formed of a double row of cells, and hence thickened, as in *Tortula marginata;* in some cases entire, in others variously toothed. In some species, *Weissia controversa*, for instance, it is involute (*rolled over towards the upper surface*); in others revolute (*rolled over towards the lower surface*), as in *Tortula revoluta*, to be found on wall tops; or the leaf may be rolled upon itself from side to side, or convolute, as in the leaves surrounding the base of the fruit-stalk of *Tortula convoluta*, and in some cases, as in *Atrichum undulatum*, the margin is undulated. The leaf-surface is usually smooth, but in some species, such as *Thuidium tamariscinum* (fig. 23, 2 *a*), it is covered with minute projections, and is termed papillose.

The leaves vary in colour, being of every shade of green, in some cases reddish, in others brown, or again, as in *Leucobryum glaucum*, nearly white.

Mosses are often termed flowerless plants, which is a misnomer, as both male and female flowers occur on these plants, and may readily be found in most species when the leafly stem has arrived at maturity. In many of our mosses, as in the *Bryums* and *Polytrichums*, they occur as star-like bodies at the top of the stem; in others, such as the common *Hypnum rutabulum*, both male and female flowers may be found as bud-like bodies in the axils of the stem-leaves. In the bog-mosses, or *Sphagnums*, they occur in pendulous catkins, which are often tinged with red or brown.

FIG. 6. *Funaria hygrometrica*. *A*, an antheridium bursting; *a*, the antherozoids (×350). *B*, the antherozoids more strongly magnified; *b*, the mother cell; *c*, free antherozoids of *Polytrichum* (×800).

If these flowers are dissected, it will be seen that they consist of a number of leaves surrounding or enveloping the organs of reproduction, the Antheridia (fig. 6 *A*), (*bodies which perform the function of an anther*), *i.e.* the male; or the Archegonia (fig. 7 *B*), (*bodies which perform the function of a pistil or ovary*), *i.e.* the female reproductive bodies.

The leaves surrounding the antheridia form what is termed the perigonium (*that which surrounds the male organ*); those surrounding the archegonia form the perigynium (*that which surrounds the female organ*). The male flowers

are sometimes developed in the axils of the ordinary leaves, and have no perigonium, as in *Sphagnum.*

Mosses are said to be synoicous when male and female organs occur in the same enveloping leaves (fig. 28, 4), as in *Mnium subglobosum;* monoicous when these organs occur in different buds on the same plant, as in *Hypnum rutabulum;* dioicous when the male organs occur on one plant and the female on another plant of the same species, as in *Ceratodon purpureus.*

The antheridia (fig. 6 *A*), are sac- or sausage- shaped bodies, and are usually surrounded by a number of thread-like jointed bodies, called the paraphyses (Gr. *para*, beside, and *phuo*, I grow). The function of these bodies is probably that of nutrition. In the Sphagnums these paraphyses are absent, and the antheridia are very differently shaped, consisting of a short stalk, surmounted by a globular head, the antherozoids being developed in the globular head; these antheridia may be readily obtained by carefully dissecting away the leaves of the catkins, which are usually reddish or brown, and often occur near the summit of the stem. If the antheridia of ordinary mosses are examined microsopically with a $\frac{1}{4}$ or $\frac{1}{6}$-inch objective, they will be seen to contain a number of closely packed cellules, and in each of these cellules a spiral, thread-like body may be seen. This spiral body is the antherozoid, or fertilizing principle of the antheridium ; and, supposing that the antheridium is ripe, a very slight pressure of the cover glass will cause it to burst at the apex, and the inclosed cellules will be seen swarming out with a sort of jerky motion (fig. 6 *a*). In a few minutes the cellulose coat of the cellules is dissolved, and the spiral bodies, the antherozoids (fig. 6 *c*), thus liberated, commence moving about in the water, much like some infusoria.

This beautiful sight may be seen readily, and the star-like male flowers of Polytrichum are the most easily examined. These should be got about the end of May or in June. The outer leaves of the flowers should be dissected away, and some of the ripe antheridia should be examined in water with the 4-10th or $\frac{1}{4}$-inch objectives.

The archegonia (fig. 7 *B*), which, with the exception of the Sphagnums, are also surrounded by paraphyses, are somewhat flask-shaped bodies, the upper part consisting of a slender neck, the lower part being somewhat pear-shaped. In the centre of the pear-shaped body, and near the top, is a small cavity, within which a nucleated cell is developed, called the oosphere (fig. 7, *B b*); and after the archegonium has acquired some size, a closed canal will be seen passing down the neck, into that part of the pear-shaped body in which the oosphere (fig. 7, *B b*) is situated. After a while, as growth goes on, the cells bounding the top of the neck fall away, thus leaving an open passage down the canal to the oosphere. Down this canal the antherozoids pass, and reaching at length the oosphere bring about impregnation.

FIG. 7. *Funaria hygrometrica*. *A*, longitudinal section of the summit of weak female plant (× 100); *a*, archegonia; *b*, leaves. *B*, an archegonium (× 550); *b*, ventral portion with the centre cell; *h*, neck; *m*, mouth still closed. *C*, the part near the mouth of the neck of a fertilized archegonium, with dark-red cell walls.

After impregnation has taken place cell-division commences in the oosphere, and continues until by frequent repetition the sporogonium is formed. During this time the archegonium increases in size, the sporogonium (fig. 8, *B f*) growing longitudinally, and striking deep down into the base of the archegonium. This continued upward and

downward pressure on the delicate tissues of the archegonium causes it to rupture near the base; the upper part being carried upwards by the growing sporogonium (fig. 8, *B c*), forms the hood or calyptra, the lower part is left sur-

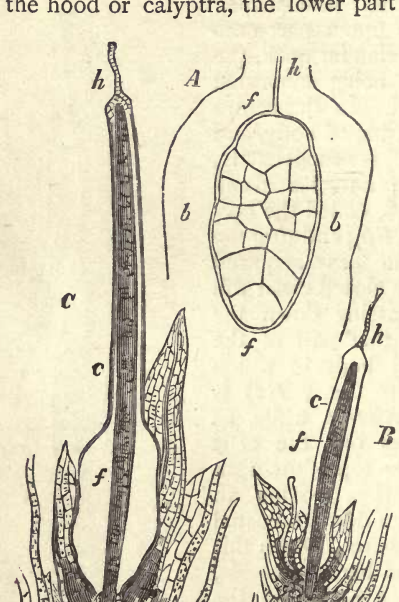

FIG. 8. *A*, origin of the sporogonium. *f f* in the ventral portion of the archegonium (longitudinal section × 500). *B*, *C*, different further stages of development of the sporogonium, *f*, and of the calyptra, *c*; *h*, neck of the archegonium (× about 40).

rounding the base of the sporogonium and forming a sheath, which is called the vaginula (Lat., a little sheath). At the top of the sporogonium the capsule is formed, within which the spores are developed.

If longitudinal and transverse sections of the unripened capsules of mosses, in various stages of growth, be cut for microscopical examination,* these will form valuable aids to the study of the growth and development of the capsule and the spores.

If a good section is made through a fully formed but unripened capsule of *Funaria*, care being taken to choose a nice, plump, green specimen, and this section be examined with a power of about 140 diameters or more, the structures to be observed will be as follows :

Beginning with the outer portion of the section, there is first a single layer of cells, forming the outer wall of the capsule (fig. 9 *f*). These are thick-walled cells, which become hardened as the fruit ripens, are truly cuticular, and have occurring among them at intervals *stomata*, similar to those found on the cuticle of the leaves of flowering plants. These cells in ripening are often deeply coloured, assuming in the different species various shades of brown, yellow, purple, at times almost black, and in some cases blood red. The next layer or lining membrane of the capsule is formed of two or more series of large, thin-walled, spongy cells, more or less filled with the green chlorophyll granules. Next after this is the air cavity (fig. 9 *h*). This air cavity is intersected by numerous jointed alga-like cells, richly charged with chlorophyll. These are attached to the lining

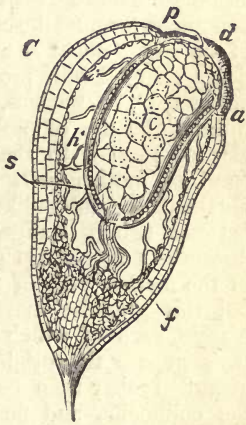

FIG. 9. *Funaria hygrometrica*. Longitudinal section of the theca or capsule, bisecting it symmetrically ; *d*, operculum ; *a*, annulus ; *c*, columella ; *h*, air cavity; *s*, the primary mother cells of the spores ; *f*, outer wall of capsule ; *p*, peristome, or fringe.

* Directions for cutting these sections will be found in the last chapter of this work.

membrane of the capsule, and proceed from that to the central body, the columella (fig. 9 *c*), to which they are attached in every direction, their function being that of holding this in position until the delicate band of cells clothing its outer side are properly developed. The alga-like cells are absorbed before the capsule arrives at maturity.

Occupying the centre of the capsule, and suspended from the operculum, is a central mass, which consists of two distinct layers of cells; the first and outer layer being that forming the mother cells of the spore band (fig. 9 *s*), and the inner mass forming the columella (fig. 9 *c*). The mother cells of the spores occur as a band or layer of small, opaque cells richly charged with protoplasm, in which is embedded the nucleus. The nucleus, which cannot always be detected without the use of proper re-agents, is attached by protoplasmic threads to the walls of the containing cell. The band of mother cells of the spores may sometimes be obtained in ribbon-like plates, by pressing the capsule between two glass slips, as in *Tortula lævipila;* but in most instances it breaks up under such treatment. At first each of the mother cells of the spores is filled with protoplasm; but this granular mass soon becomes divided into four masses, each of which secretes an outer cell wall, and by their growth the original cell wall of the mother cell is absorbed; they then become free from their attachment to the columella, and float freely in a mucous fluid, which together with them fills the cavity of the capsule. The cells thus formed are the spore mother cells, and these, by a merismatic division of the cell contents, each gives origin to four masses, which in their turn secrete a new cell wall, and by their growth absorb the containing cell wall and become the spores. The mucous fluid is absorbed during growth. In many bryums and orthotrichums the primary cell wall still remains attached until the spores are nearly ripened, holding the spores together, even when fully formed, by these threads of the old cell wall.

Much interesting information on this head may be gained by examining the inner contents of capsules in the various stages of growth, and this may be most conveniently done

by pressing out these contents between two glass slips. The contents should be examined in water, and, if desired as a permanent record, may be mounted in glycerine or one of the compounds of that agent.

The columella (fig. 9 *c*), or central mass, hangs, as it were, from the lid of the capsule, and is held in position by the chains of alga-like cells, which are attached to it in all parts. This columella is formed of large, pale, parenchymatous, thin-walled cells; originally it fills the whole centre of the capsule, but is afterwards divided from the cell walls by the differentiation of certain of the cells to form the mother cells of the spores and by the air cavity. After the spore mother-cells are formed, the columella usually perishes or shrivels up, the whole cavity of the capsule being filled with the spores. But in some cases it is persistent, as in the sub-genus *Schistidium* and in *Pottia*, where it remains attached to and falls away with the lid (fig. 4, 2 *a*), and in the genus *Polytrichum*, where, whilst the lower portion perishes, the upper portion still remains, forming the beautiful diaphragm which closes the mouth of the capsule in this genus (fig. 15, 3 *a*).

Examining the section still further, we notice that at its apex is a dome-like series of thickened cells; this is the operculum (fig. 9 *d*) as seen in section. Immediately at the base of the operculum, and, as it were, separating it from the mouth of the capsule, is a row of peculiar cells, forming the annulus (fig. 9 *a*); but these cells are only distinctly seen when the section is very thin, and with the higher magnifying powers of the $\frac{4}{10}$ or $\frac{1}{4}$-inch objective. The cells forming the annulus are very elastic when mature, and by their expansion throw off the operculum. The annulus is sometimes formed of a single, sometimes of a double row of cells, and is sometimes absent, as in *Tortula anguiculata*, its presence or absence often forming an important aid to the determination of nearly allied species. Proceeding from the top of the air cavity, and inclosed by the operculum, are the layers of cells forming the peristome (fig. 9 *p*), the outer peristome proceeding and originating from the lining membrane of the capsule, and the inner one from the outer

layer of cells of the spore sac. These two layers of cells, when ripened, form those beautiful fringes which adorn the mouths of many moss capsules, but in many other species the peristome is absent or very rudimentary; their presence or absence, or whether single or double, are useful in the discrimination of genera, and a study of their structure is in some cases a valuable aid to the determination of species.

By virtue of the insertion of the fruit-stalk, mosses are divided into two sections,—Acrocarpi, or those mosses which have the fruit-stalk terminating the main stem (fig. 4), as in *Pottia truncata* and—Pleurocarpi, or those mosses which have the fruit-stalk arising from the side of the stem (fig. 5), as in *Hypnum rutabulum.*

The fruit-stalk, which is always present, varies in length; in some cases, as in *Phascum serratum*, it is very short; in other cases it may be long and conspicuous; it is usually smooth, but sometimes the surface is distinctly roughened or granulated, as in *Hypnum rutabulum* (fig 5, 2 *b*). It may be straight or variously curved.

The base of the fruit-stalk is surrounded by leaves, which in some species differ remarkably in both form and structure from the other leaves of the plant (fig. 5, 2 *c*). These are the perichætial leaves, and the character of these leaves often forms a special feature in the description of mosses. If these leaves are carefully removed, it will be seen that the base of the fruit-stalk is surrounded by a membranous sheath, the vaginula, already mentioned; this is usually smooth, but in some species it is more or less clothed with hair-like processes, and these minute differences are in some cases great aids in the discrimination of nearly allied mosses.

At the top of the fruit-stalk is the capsule, or urn; and this organ presents great variety in its form, in some cases globose, *Phascum cuspidatum;* pear shaped, *Leptobryum pyriforme;* cylindrical, *Tortula aloides;* straight, curved, or erect, *Tetraphis pellucida;* cernuous (curved to one side), as in *Hypnum rutabulum* (fig. 5); or pendulous, as in many of the Bryums; it may be smooth, striated, or furrowed.

In some species the capsule is swollen all round at the

base, and this swollen part is called the apophysis (fig. 10 *c*), as in *Splachnum ampullaceum;* this apophysis may be seen at the base of the capsules of *Polytrichum commune*, but not so exaggerated as in Splachnum; sometimes the swelling is confined to a little bulging out of one side of the base of the capsule, as in *Dicranum falcatum*, or in *Dicranella cerviculata*, or *Ceratodon purpureus*, &c.; the capsule is then said to be strumose.

The capsule is surmounted by a membranous hood called the calyptra, already mentioned as being developed from the upper portion of the fertilized archegonium (fig. 11, 2; fig. 12, 3). In some genera, such as the Bryums, this hood falls away early, and hence is not seen upon the mature capsule; but in many other genera, such as Tortula, Hypnum, etc., it is persistent and may readily be seen. In the act of separation from the lower part of the archegonium, or vaginula, the calyptra is sometimes irregularly torn at its base, as in *Grimmia apocarpa*, or it may be evenly torn, as in *Encalypta vulgaris*. In both cases the calyptra is termed mitriform or mitre-shaped (fig. 11, 2). In many other mosses it is slit up one side, and is then said to be dimidiate (fig. 12, 3), (Lat., *dimidium*, a half), or it may be inflated, as in Funaria, and these characters are constant. Usually its outer surface is smooth, but in some species it is papillose, and in others more or less densely clothed with hairs, as in Orthotrichum and Polytrichum.

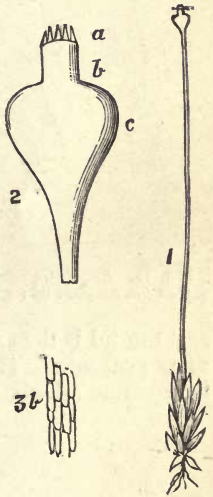

FIG. 10. *Splachnum ampullaceum.* 1, plant natural size. 2, fruit enlarged; *a*, peristome; *b*, cylindrical capsule; *c*, obovate apophysis.

The mouth of the capsule is closed with a little lid called the operculum, and between the lid and the mouth of the capsule a ring of minute, highly hygroscopic cells frequently

occurs, called the annulus (Lat., a ring). The function of this ring is that of casting off the lid when the spores are ripened, and thus aiding their dispersion; but in many mosses, such as *Tortula unguiculata*, there is no annulus,

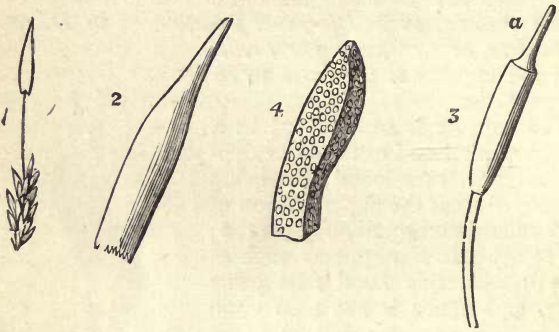

FIG. 11. *Encalypta streptocarpa*. 1, plant natural size. 2, mitriform calyptra. 3, fruit; *a*, subulate lid; 4, leaf magnified.

and the lid is then cast off by the swelling of the contents of the capsule. The operculum is not always present, and here nature adopts other means to bring about the disper-

FIG. 12. Urn or capsule of *Pottia intermedia*. 1, naked mouth of urn. 2, beaked or rostrate lid (operculum). 3, dimidiate calyptra.

sion of the spores; in the Andreæas, or split-mosses (fig. 13), the capsule splits into four valves (fig. 13, 5), and in the Phascums (fig. 14, 1), or earth-mosses, the capsule bursts

irregularly, or rots away, and in its decay liberates the spores.

The lid or operculum varies in form, being sometimes convex, as in many of the Bryums, or conical (fig. 15, 3), as in *Physcomitrium pyriforme*, *Tetraphis pellucida*, etc.; or it may be rostrate (beaked) (fig. 12, 2), as in *Dicranella heteromalla*, etc.

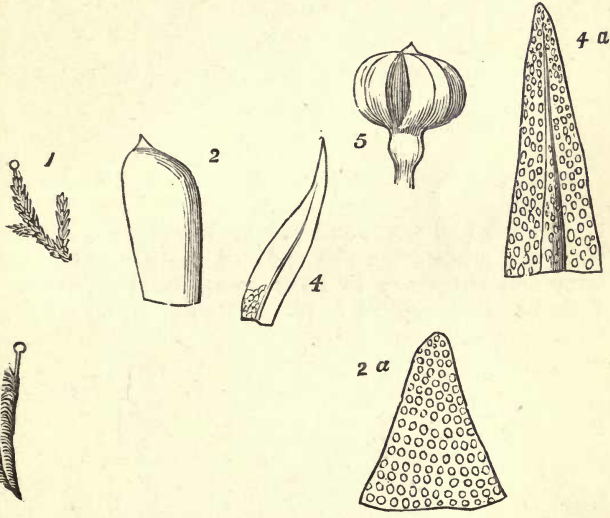

FIG. 13. *Andreæa alpina*. 1, plant natural size. 2, nerveless leaf magnified, 2 *a*, apex of same, to show dot-like, thick walled upper cells.
Andreæa nivalis. 3, plant natural size. 4, nerved leaf enlarged; 4 *a*, apex of same to show areolation. 5, capsule bursting (dehiscing) by four valves.

When the lid is removed, or has been cast off naturally, the inner structure of the capsule may be seen, and in some mosses, such as *Pottia truncata*, the mouth will be found to be naked, but in many other cases it will be seen to be surrounded by a delicate, fringe-like appendage, called the peristome (fig. 15, 2), (Gr. *peri*, around, and *stoma*, a mouth). This fringe consists of minute tooth-like processes, which

are always some multiple of 4 in number, from 4 to 64, and the number is always constant in the species. This fringe may be either single (fig. 15, 2), or double; that is, there may

FIG. 14. 1, indehiscent capsule of *Phascum cuspidatum*. 2, dimidiate calyptra.

be an outer (fig. 5, 3 *b*) and an inner row (fig. 5, 3 *a*) of these tooth-like processes. The teeth of the peristome vary in form and structure; in some cases, as in certain of the Weissias, they are very rudimentary; in others, as in

FIG. 15. Capsule of *Grimmia*. 1, urn. 2, peristome. 3, conical lid or operculum.

Funaria, they are elaborately developed, and beautifully marked with transverse and longitudinal striæ or markings. The teeth are often simple, but may be cloven, as in *Dicranella heteromalla;* sometimes straight, as in *Didymodon rubellus;* or much twisted, as in *Tortula muralis*, etc. In the Polytrichums the mouth of the capsule is closed by a beautifully reticulated diaphragm (fig. 16, 3 *a*), to which the

teeth of the peristome are attached. This is peculiar to the family of Polytrichaceæ, so far as British mosses are concerned.

The study of the development of mosses is one of very great interest, and worthy of the attention of all biological students. Space is too limited to allow the matter to be dealt with here in anything like fulness, and I must there-

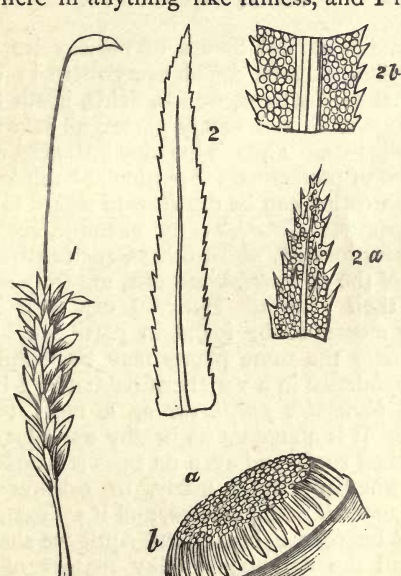

FIG. 16. *Atrichum undulatum.* 1, plant natural size. 2, leaf enlarged; 2 *a*, apex of same more highly magnified. 2 *b*, middle of same, to show areolation and lamellate nerve. 3, a portion of the fruit enlarged; *a*, diaphragm or drum; *b*, peristome; *c*, capsule.

fore refer those students who desire fuller information to that grand work of Hofmeister's (Ray Society's publications) on the "Germination, Development, and Fructification of the Higher Cryptogamia," pp. 129–181, where a most elaborate and exhaustive account will be found.

III.

MOSS HABITATS.

THE habitats or natural homes of mosses are very varied. In fact, mosses may be found everywhere in country districts, so that banks, trees, woods, fields, heath lands, walls, marshes, bogs, and other watery places, all have their several mossy inhabitants. Though in many instances mosses show some degree of preference for particular habitats, no positive line of demarcation can be drawn with regard to the habitats of some species. *Ceratodon*, for example, seems to be at home in every locality, whilst others, such as the *Sphagnums* and many of the *Orthotrichums*, etc., are truly selective with regard to their haunts. Hence I can only indicate the most likely mosses to be found in particular habitats. In many instances the same plants may be found flourishing in equal abundance in a variety of habitats. I have already mentioned *Ceratodon purpureus* as a moss to be found everywhere. It is abundant on heathy waysides, and on old walls, thatched roofs, and even on trees it is no less plentiful.

Banks, whether sandy, marly, or calcareous, are the favourite haunts of many mosses, and if we examine a damp sandy bank between February and April we shall be almost sure to find the dark-green, silky masses of *Dicranella heteromalla*, easily known by its terminal fruit-stalk, which is pale in colour and is abruptly bent back just below the capsule. The leaves will be found to be very narrow and all curved in one direction, and the capsule surmounted by a lid having a longish beak; the peristome or fringe consists of sixteen teeth, each of which is split half way down.

In like places we shall also find *Weissia controversa*, which has straighter leaves, with the margins rolled over towards the upper surface, erect oval capsules, lid with a long, straight beak, and a fringe of sixteen rudimentary

teeth; when dry, the leaves will be found to be much twisted. Smaller tufts of the apple moss, *Bartramia pomiformis*, may also be found, and it may be known, even when barren, by its glaucous, green foliage (fig. 17). The capsules of this moss are apple shaped, and surmounted by a slightly convex lid. The fruit ripens in early summer.

Hypnum prælongum will be frequently seen fruiting about November, but very often barren. In the barren state it may be known by its long, trailing, feathery stems, which however vary very much in habit. When in fruit it will be known by its long, roughened fruit-stalks (which are lateral, as in all Hypnums), curved capsules, and lid with a long, curved beak; the fringe is in two rows, an outer one formed

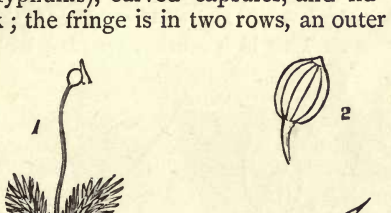

FIG. 17. *Bartramia pomiformis.* 1, plant natural size. 2, ribbed capsule enlarged. 3, dimidiate calyptra.

of sixteen teeth, and an inner, paler, membranous one, divided into sixteen tooth-like processes. *Hypnum rutabulum*, another of the feather mosses, is more robust, has heart-shaped leaves, roughened fruit-stalk, and a shorter conical lid (fig. 5). *Hypnum velutinum* is much smaller, and has narrower, lance-shaped leaves, and is more velvety looking; whilst *Hypnum confertum*, which is constantly associated with the above, has a *smooth* fruit-stalk, and lid with a longish, curved beak.

Many other mosses will also usually be found in like habitats; such as *Plagiothecium denticulatum*, which will be found on damp sandy banks and hedge bottoms, forming large, spreading, pale-green glossy, masses. It will be noticeable for its flattened (complanate) leaves, usually growing in two

opposite rows, with an abundance of purple fruit-stalks, capped by the slightly inclined capsule, which has a conical lid. The fruit-stalks are usually inserted near the base of the stem, and examination with a lens will show the male flowers immediately below the fertile flowers. *Hypnum purum* will also frequently be found in such places, growing in great, scrambling masses. This moss has a beautifully pinnate stem; the leaves are pellucid, light, glossy green, very concave, blunt, and terminated by an abrupt, recurved point. The fruit, which is very rare, must be looked for in November. On the lower part of these banks, coating any stray stone, or broken bough or tree root, and forming dense, matted patches of bright green, *Amblestegium serpens* will be frequent. This is a minute species, with abundant

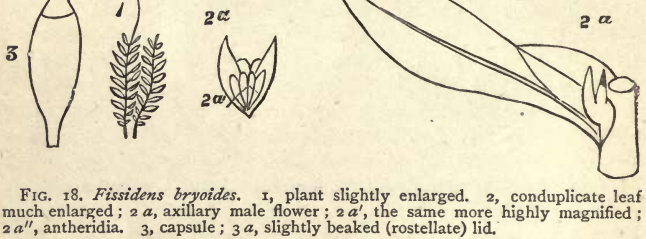

FIG. 18. *Fissidens bryoides.* 1, plant slightly enlarged. 2, conduplicate leaf much enlarged; 2 *a*, axillary male flower; 2 *a'*, the same more highly magnified; 2 *a''*, antheridia. 3, capsule; 3 *a*, slightly beaked (rostellate) lid.

thread-like branches; it will usually be found in abundant fruit, a noticeable character being the little white calyptra which surmounts the capsule. This will be in good fruit about April or May.

Marly and clayey banks will yield such mosses as *Fissidens bryoides* (fig. 18, 1), a very beautiful little moss, known by its flattened foliage, with leaves on opposite sides of the stem, looking very fern-like, fruit-stalk arising from the top of the stem and surmounted by an erect reddish capsule, with a cone-shaped lid, and a fringe of sixteen bifid teeth. The fruit of this moss ripens from October to the end of the year. A larger species, *Fissidens taxifolius*, will frequently occur with this; but the fruit-stalk arises from the base of

the stem, the capsule is somewhat curved, and has a longish beak (fig. 20, upper fig.); fruit ripe in November. A species similar to *F. bryoides* is also frequent in Warwickshire; this is readily distinguished from it by the capsule, which is curved to one side. This is *Fissidens incurvus*. This species ripens its fruit about February or March.

Another moss, frequent on banks such as I have described, is *Tortula unguiculata*. It may be known by its somewhat tongue-shaped leaves, terminated by a small mucro or point, and having the margin recurved, or turned towards the lower surface; the fringe of the peristome consists of thirty-two spirally twisted teeth. It fruits from December to April. A close ally, *Tortula fallax*, not unfrequent, has leaves tapering from the base, a more curved capsule, and fringe also twisted. Another frequenter of marly banks is the minute *Dicranella varia*, which occurs in patches of a reddish green colour. It has narrowly lance-shaped nearly erect leaves. The capsule is small and slightly inclined to one side, and the conical lid has a very short beak; the fringe consists of sixteen deeply divided teeth. It fruits about November.

A more rare species, *Dicranella rufescens*, will occasionally be found growing with this, and may be distinguished by the erect capsule and more conical lid or operculum. Under the microscope the leaves will be found to have a different texture; those of *D. varia* having narrow close cells, whilst *D. rufescens* has large, pellucid cells, the leaf-margin is toothed or serrated, and the whole plant has a more or less reddish hue. In northern districts, the clay banks will occasionally yield the very interesting *Discelium nudum*, which may attract attention by its dense masses of confervoid-like protonema, in which will be seen scattered patches of tufted leaves. The stem being almost absent, these little tufts are dull green, or sometimes, after severe weather, of a reddish tinge. But about March the attention will be arrested by the abundant reddish, wavy fruit-stalks, bearing at their summit a somewhat drooping capsule, which has a slightly beaked lid; and these fruit-stalks will appear the more singular because, owing to the very slight develop-

ment of the stem, they appear to arise from amidst the confervoid mass above mentioned, and seem at first sight to have no leaves.

Dry banks in maritime situations should be searched for the somewhat rare *Tortula atro-virens*. The stems are short, forming dense tufts. The leaves are broad, concave, with a slight point, and slightly spreading when moist, contorted or twisted when dry. The most noticeable feature is the strong, spongy leaf-nerve, curiously thickened in the upper part. The fruit-stalk is terminal, short, capsule oval, shining, lid slightly beaked, peristome single, of sixteen teeth. Fruiting in March.

Marly banks will also yield *Camptothecium lutescens*, a fine moss, growing in rather loose yellowish-green or fulvous masses. Stems more or less prostrate, branched and spreading; leaves bright yellowish-green, loosely imbricated, lance-shaped, rigid, and strongly striated. The fruit-stalk is lateral, and more or less covered with little prominences. Capsule slightly curved, and lid somewhat beaked. Fruit rare; April.

Anomodon viticulosum (fig. 37), mostly occurring in marly soils, will be found covering tree roots or outcropping rocks with dense masses of verdigris green. The leaves are blunt, imbricated on all sides, slightly spreading when moist, much curled and twisted when dry, and turning yellowish when old. The fruit is rare, but will be found most frequently where the plant has a good supply of moisture. The fruit-stalk is lateral, and the fruit will be found about November.

Tortula aloides and *T. ambigua* frequently occur together on marly and clayey banks. They are very closely alike, and can only be separated by careful examination of minute details, but may be known from other species occurring in like habitats by the short stem, dark-green, somewhat fleshy leaves, with the margins very much incurved. The capsule is cylindrical and erect in *ambigua*, and slightly inclined in *aloides*. The fringe is only slightly twisted.

Banks in calcareous and chalky districts will yield many of the foregoing species, but will also have among its denizens species peculiar to such soils. Such as the *Selegerias*, *Eucladium verticillatum*, *Encalypta vulgaris*, *Grimmia*

orbicularis, *Ditrichum flexicaule*, *Pottia lanceolata*, *Mnium stellare*, *Trichostomum tophaceum*, *Bartramia calcarea*, etc.

The *Seligerias* are minute species, most likely to be found on jutting rocks in calcareous districts, and possibly the species most frequent will be *S. pusilla*, which will be found growing in light-green patches. As it is a very minute species, only close observation will detect it. Usually it occurs in fairly dense masses, and may be recognised by its small, awl-shaped leaves, straight fruit-stalk, and small, top-shaped capsule. It will be in fruit in April or May. Another very characteristic calcicolous moss is *Eucladium verticillatum*, which appears to favour moist rocks among trickling water, and usually the stems will be found more or less encrusted with a calcareous deposit. The stems vary from half an inch to two inches in height, and it occurs in dense, pale, bright-green tufts. Although this moss really belongs to the acrocarpous or terminal-fruited section, it may appear to the novice to be a lateral-fruited species, owing to the lateral prolongation of the branches. The leaves are narrow, rigid, and strongly nerved. Capsule erect, oval, glossy, reddish; peristome simple, of sixteen teeth; fruit ripe in June. It may be mentioned, in passing, that when this or any other calcicolous species is intended to be mounted in glycerine or any glycerine compound, it should be first of all soaked for a short time in dilute nitric acid, to dissolve the calcareous matter adhering to the stem, and then well washed in water, otherwise the chalky particles will effervesce in the glycerine, and so spoil the preparation. *Encalypta vulgaris* will also occur on these banks, and this species will be readily known by its large, pale-green, extinguisher-like calyptra (fig. 11, 2), which covers the whole capsule, the large leaves, twisted when dry, and cylindrical capsules. It will be found in fruit in April, and may be known from other species of the same genus by the calyptra being entire at the base. In the other species, the calyptra is always toothed or fringed at the base, with fine, hair-like processes. *Grimmia orbicularis* should also be sought in such districts, but may be looked for on calcareous rocks rather than banks (fig. 19, 4). It

grows in dense cushions, very similar to the familiar *G. pulvinata* (fig. 19, 1), from which however it may be known by the convex lid—that of *G. pulvinata* being beaked,—and by the calyptra being split on one side, and not five-lobed as in the latter species, and by its fruit being ripened about a month earlier than in the latter species. *Ditrichum flexicaule* occurs in loose, glossy, yellowish-green tufts, one or two inches high. The leaves are spreading, lance-shaped, and narrowed into a longish, awl-shaped point. Under the microscope the nerve will be seen to form all the upper portion of the leaf. The stems are somewhat matted together by root-like processes. This moss is always barren in British districts. *Pottia lanceolata*, which grows in large patches, will be frequent in such soils. The stems vary in length from half to one inch high, the leaves are lance-shaped, terminated by a hair-like point, fruit-stalk terminal, capsule egg-shaped, brown and smooth, peristome single, of sixteen teeth. *Mnium stellare* occurs both in calcareous and marly soils, on shady banks, growing in dense tufts of full green or bluish green colour. The leaves are oval, lance-shaped, without the thickened border usual in these species. The leaf-cells are dense and roundish, and the leaf-margin is serrated. This species has not yet been found in fruit in Great Britain. *Trichostomun tophaceum* is a native of moist, dripping banks in calcareous and marly soils, growing in densely tufted masses, often matted together

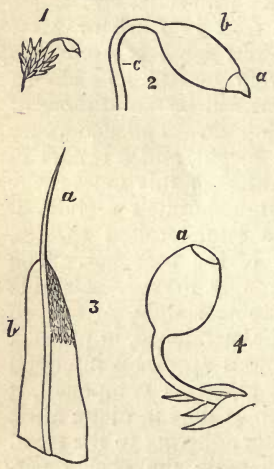

FIG. 19. *Grimmia pulvinata*. 1, plant natural size. 2, fruit enlarged; *a*, conico-rostrate lid; *b*, capsule; *c*, curved seta. 3, leaf enlarged to show hair-like prolongation of nerve; *b*, areolation. 4, *Grimmia orbicularis*, to show convex lid *a*.

with earthy deposits, dull deep green in colour, and will be recognised by the lance-shaped, blunt, keeled leaves, having a strong nerve scarcely reaching the leaf tip. The fruit-stalk is terminal, the capsule erect and egg-shaped, peristome of sixteen teeth, lid conical with an oblique beak, fruiting in November. *Bartramia calcarea* may be found in wet places in calcareous or marly soils, and has somewhat the appearance of *B. fontana*, from which it may be known by the intense and beautiful green colour of its leaves. The leaves are more rigid, destitute of border, with larger cells; and the leaves of the male flower are acute and nerved to the apex, those of *B. fontana* being obtuse and nerveless.

A moss-grown tree is always an attractive object to me, and many a pleasant hour has been spent looking over these mossy invaders in search of some rare or local species. The trees most prolific in moss tenants in Warwickshire (better known to me than any other county) are the ash, elm, lime, Ontario poplar, sycamore, and apple. The oak is often moss-grown, but not to the extent of the above-mentioned, nor are its inhabitants so truly tree-loving species. On the beech and the coniferæ I rarely find mosses. In other climates these also have their special tenants. The mosses which I should designate tree-loving mosses are such as the *Orthotrichums, Cryphæa, Leucodon sciuroides, Zygodon, Weissia cirrhata, Leskea polycarpa*, etc.

The Orthotrichums are very distinct-looking mosses, occurring in larger or smaller tufts. The fruit-stalks are very short and usually hidden by the surrounding leaves. The capsules, with one exception, are striated or streaked (fig. 20, 2), and always erect, the calyptra bell-shaped (fig. 20), longitudinally plaited, and more or less covered with erect hairs, the leaves in most cases erect when dry, and more or less covered with minute papillæ, and the leaf-margin in most cases turned over towards the under-surface or revolute, leaf-cells roundish. If the above characters are borne in mind they will be great helps.

Orthotrichum affine will be found frequently on the ash, elm, and poplar, in large, loose, dark-green tufts, a rather coarse-looking moss, with a pale, yellowish-green calyptra.

The capsule is oblong, pale brown, with a longish straight beak when ripe, but becomes whitish and somewhat spindle-shaped when dry.

O. Lyellii is abundant on the elm and ash, forms large yellowish-green loose tufts, has the leaves much recurved when moist, twisted when dry, the leaf-margins plane, and both surfaces covered with prominent papillæ or minute elevations, and much clothed with brownish jointed conferva-like processes. The fruit very rare.

FIG. 20. Upper figure, *Fissidens taxifolius*, fruit-stalks lateral. Left-hand figure, 1, pear-shaped capsule, and, 2, convex operculum of *Funaria fascicularis*. Central figure, *Zygodon viridissimus*. Right-hand figure, *Orthotrichum affine*; *x*, plant natural size; *b*, calyptra. 2, striated capsule and hairy calyptra, enlarged.

O. diaphanum will be found on many habitats, trees, old palings, walls, etc. It grows in small, bright-green tufts, and has the leaves terminated by translucent toothed whitish tips.

O. leiocarpum is rare in the Midlands, and is readily known from the other species by the capsule, which is quite smooth, *i. e.* without striæ, when dry. This I find on the Ontario poplar.

The Ulotas have most of the characteristics of the Orthotrichums, but have usually more hairy calyptras, and narrower leaves, much crisped when dry.

Ulota intermedia, which occurs on both elm and ash, forms little yellowish-green tufts, and has the leaves much twisted when dry. From May to July is the best season for all the above in perfect fruit.

Cryphæa heteromalla is a local moss, occurring mostly on

the ash, has a creeping pinnate stem, fruiting branches erect, the capsule immersed in the surrounding leaves, the calyptra conical, brownish, and the fringe or peristome white. Fruiting in June.

Leucodon sciuroides I find upon the ash, elm, and apple trees, often very abundant, but very rarely fruiting. This species has also a creeping stem, with numerous erect shoots; the leaves are spreading when moist, but imbricate (overlapping) when dry; the shoots are thickened at the end and incurved, and the leaves are nerveless; marginal leaf-cells round, central ones oblong.

In calcareous and marly soils I find the yellowish-green tufts of *Zygodon viridissimus* (fig. 20, central figure) not unfrequently on the lower part of the trunks of elm, ash, and sometimes oak trees; when moist and fresh-gathered the leaves are spreading, but when dry they are crisped and somewhat twisted; the leaves are widely lance-shaped, have plane margins, very small dot-like cells, and a pellucid nerve. I have not seen this in fruit, but it should be sought for in spring.

FIG. 21. 1, *Mnium undulatum*. 2, *Mnium hornum*.

Weissia cirrhata is an abundant moss on trees, gate-posts, and rails, forming dark-green cushions. The leaves are lanceolate, with the margins turned over towards the under-

side, crisped when dry, leaf-cells minute and opaque; the capsule is terminal, borne on a short, straight foot-stalk, has a long straight beak, and a fringe of sixteen rudimentary teeth.

Leskea polycarpa I have found most frequently on the roots of willows, especially near water, but it also occurs in drier habitats. It forms matted yellowish-green tufts; the stem is creeping, somewhat divided with pinnate branches, leaves spreading, somewhat oval in shape, slightly roughened or papillose on the back, leaf-cells roundish. The fruit-stalk is lateral, the capsules erect and the lid conical, the fringe consisting of an outer and an inner row of sixteen teeth.

Woods will yield many of our most beautiful mosses, the borders where the shade is not too great being usually the most prolific spots. Many of the species already mentioned will be found, but the most characteristic are such mosses as *Mnium undulatum*, *Polytrichum formosum*, *Hypnum tamariscinum*, *H. triquetrum*, *Dicranum scoparium*, *Mnium hornum*, etc.

Mnium undulatum is a very noble-looking moss, not unfrequent in shady woods and on shady banks in a marly soil (fig. 21, 1). It grows in large green patches, and has a very tree-like habit; the leaves are tongue-shaped, obtuse, with a slightly thickened margin, which is toothed with distinct simple teeth; towards the top of the stem the leaves form a rosette, and from this arise arched or pendulous whip-shaped branches. The leaves are undulated when moist, crisped when dry. The fruit, which is rare, is terminal, the fruit-stalks are long, and the capsules pendulous.

Mnium hornum, a denizen of like places, is far more frequent (fig. 21, 2). This grows in dense green tufts, the stems being matted together with reddish rootlets. The leaves are lance-shaped, the margin thickened and bordered by a double row of teeth; fruit-stalk terminal and arched at the top like a swan's neck; capsule oblong, slightly drooping; lid convex, with a small point; in both these mosses the fringe is double, and forms a beautiful object for the microscope. Fruiting in May or June.

Polytrichum formosum rejoices in open woods, and forms extensive loose tufts (fig. 22). The stems are often five or six inches high, and are terminated by long fawn-coloured fruit-stalks. The capsules are large, four or five angled, and

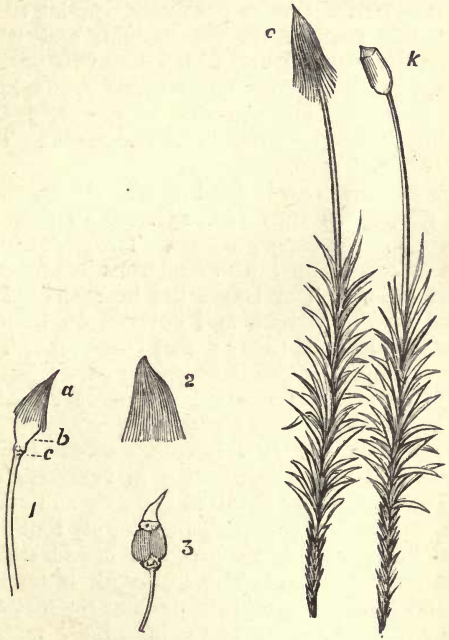

FIG. 22. *Polytrichum formosum*, natural size, *c*, *k*. 1, fruit slightly enlarged; *a*, calyptra; *b*, capsule; *c*, apophysis. 2, hairy calyptra more enlarged. 3, fruit to show rostrate lid.

slightly swollen at the base, this swollen portion being called the apophysis (fig. 22, 1 *c*). The mouth of the capsule is closed by a reticulated diaphragm (fig. 16, 3 *a*), and fringed by sixty-four short, pale teeth (fig. 16, 3 *c*). The lid is long

and rostrate (fig. 22, 3), and the calyptra is clothed with numerous down-like hairs (fig. 22, 2).

Hypnum triquetrum is frequent in many woods and on shady banks; grows in tall, rigid, shining tufts, several inches long, yellowish-green. The stems are red, and more or less branched. The stem-leaves much recurved, clasping the stem at the base, thence gradually tapering to an acute point, minutely toothed on the margin, and striated or streaked on the surface; and with a lens two parallel veins will be seen, reaching more than halfway up the leaf. The fruit-stalk proceeds from the side of the stem, bearing a short, slightly curved capsule, with a conical lid. The fringe is double (fig. 5, 3 *a*, *b*).

Hypnum tamariscinum is fond of like places, and occurs in loose, deep-green tufts (fig. 23). This is one of the most beautiful of the feather mosses. The stem is tripinnate, and more or less clothed with numerous branched thread-like bodies (villi). The leaves are heart-shaped (fig. 23, 2), toothed on the margin, and covered on both surfaces with minute projections (fig. 23, 2 *a*) (papillæ). This moss is often proliferous, *i.e.* produces young plants from various parts of its surface. Hence the old name *H. proliferum.* The fruit is lateral and very rarely seen.

Dicranum scoparium is a beautiful moss occurring on marly banks and in woods, growing in yellowish tufts (fig. 24, 1). The leaves are turned to one side and curved like a falchion, narrow lance-shaped, and sharply toothed. The nerve is well marked (fig. 24, 3 *a*), and has several projecting ridges on the back. The fruit-stalk is terminal, the capsule curved, lid long and rostrate, and the fringe consists of sixteen deep-red cloven teeth, beautifully marked with transverse bars. Fruiting in July.

A more noble-looking species, *Dicranum majus*, may also be found in woods. This moss grows in great loose masses, having stems often six inches long, and may be known from *D. scoparium* by the numerous pale fruit-stalks all arising from one point, the olive-green curved capsules, and the longer and more tapering leaves, all curved to one side, like a sickle in shape, and unaltered when dry. The two species

are often found together, but are readily separated by even a tyro if the above characters are observed. Fruiting from May to August.

FIG. 23. *Hypnum* (*Thuidium*) *tamariscinum*. 1, plant natural size, fruit lateral (pleurocarpous). 2, papillose leaf; 2 *a*, apex of same much magnified to show papillæ.

Dicranella squarrosa is much more rare, and is possibly more frequent in some of the Yorkshire woods than elsewhere. It occurs in large tufted masses on wet, dripping banks in both woods and shady places, and may be recognised at once by the remarkably squarrose leaves (*i.e.* curved downwards on all sides of the stem). In the Yorkshire districts the stem is often six inches long. The leaves are lance-shaped obtuse, and clasp the stem at the base, and are quite smooth on their lower surface. Fruiting about August.

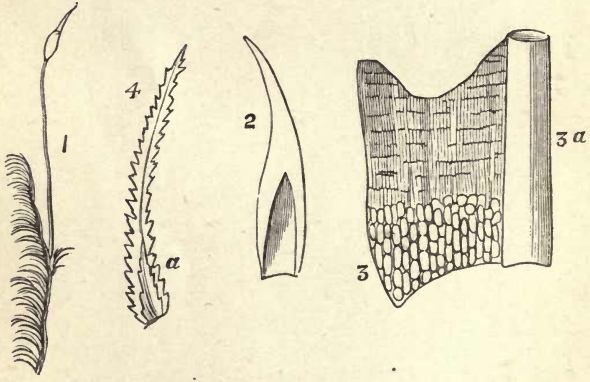

FIG. 24. *Dicranum scoparium.* 1, plant natural size. 2, dimidiate calyptra. 3, a portion of leaf to show enlarged basal cells; 3 *a*, nerve. 4, apex of leaf to show the toothed or serrated nerve, 4 *a*.

Dichodontium pellucidum, which is nearly related to the last, is far less rare, and may often be found covering the sandstone banks and rocks in streams. It grows in light-green patches, from one to two inches high; the leaves are squarrose when moist, twisted when dry, and more or less covered with minute protuberances, or papillæ, on the under surface. The leaf-cells are dot-like, and the nerve scarcely continued to the top of the leaf. Fruit, often very abundant,

may be found from October to April. Fruit-stalk terminal; capsule curved with an oblique beaked lid.

Plagiothecium undulatum grows in large flattened patches of whitish-green colour. The stems are prostrate, and the leaves distichous (*i.e.* inserted in two opposite rows), membranous in texture, egg shaped and pointed, and noticeable for the tranverse undulations which characterize them. The fruit-stalk is lateral; capsule oblong, curved, and turned to one side; lid beaked. The plant is very rare in fruit, which should be looked for in April or May.

Hypnum piliferum occurs on shady banks and in woods and is rarely found in fruit. It grows in large patches, much like *H. purum*, both in general appearance and mode of growth. The leaves are imbricated, slightly wavy, elliptical in shape, and suddenly contracted into a long hair-like point. These characters will distinguish it from any allied species.

Hypnum Schreberi is also frequent in woods, and may also be found in bushy places on heaths. It has much the aspect of *H. purum*, from which it may be known readily if the plant be held between the eye and the light, when the beautiful red stem will be seen contrasting with the yellowish green of the leaves; in *H. purum* the stem is pale green. The leaves are elliptical in shape and imbricated, concave, and terminated by a short point. Fruit-stalk lateral. The fruit is rare, and should be looked for from November to April.

A newly ploughed field, or, better still, one that has lain fallow for some little time, although presenting few charms for the general observer of Nature, will be spots to which the would-be bryologist must give his particular attention; and during those dreary months which intervene between October and April he will, if in any way an enthusiast, find plenty of work for his microscope.

The mosses to be found in such habitats are usually the simplest, from a pretty point of view the least noticeable, and the shortest lived of any he may study, and when preserved for the herbarium are, perhaps, the most disappointing, looking very often more like dried masses of mud than

aught else, still these earth mosses, or, *Phascei*, are worthy of his attention. The plan I adopt with these minuter species is not only to dry some of them with their underlying mud, but also to mount a few specimens of each on the ordinary 3in. by 1in. slips of glass, in glycerine jelly, for my cabinet, and very pretty objects many of them make when thus prepared.

The older botanists placed all the *Phascei* in the genus *Phascum;* but modern botanists, seeing that the group was a very heterogeneous one, have split these *Phascei* into several genera, such as *Pleuridium*, *Phascum*, *Sphærangium*, *Ephemerum*, *Archidium*, etc. I shall speak only of those that I have myself found most frequent.

Besides these I also find in like habitats such mosses as *Pottia minutula*, *Funaria fascicularis*, and *Tortula unguiculata.*

The *Phascei* usually occur in scattered patches, and, being minute, require the constant use of the field lens, and rather close searching in many cases. Taking their general characteristics, they may readily be known by their small bladder-like capsules, usually more or less concealed by the surrounding leaves, the fruit-stalk being very short in most species, and by the absence of a true lid or operculum.

Pleuridium subulatum is a not unfrequent inhabitant of sandy and marly fields. It may also often be found in great abundance in the cleared spaces of woods, and is in good condition about April; will be found in yellowish patches, often rather extensive; the capsule is oval, and immersed in the awl-shaped bristly looking leaves; the leaves are rigid, and have a broad nerve, which scarcely extends to the tip of the leaf; the uppermost leaves are longer than the lower ones, and much narrower.

Phascum cuspidatum is a frequent denizen of sandy fields, and occurs in small scattered light-green patches. The leaves are large for the size of the plant, are concave, oblong lance-shaped, and somewhat keeled, with the margin turned over towards the under side; the nerve projects beyond the leaf-tip, forming a short cusp-like point; the capsule is roundish and more or less hidden among the

leaves; leaf-cells quadrate, slightly papillose; spores slightly roughened.

Sphærangium muticum is much more rare, occurs in sandy and marly fields in dark-green or brownish tufts, looking to the unassisted eye like small tufts of minute bulbs. It is more minute than the last, and has broad, roundish, concave leaves, not keeled, but rounded on the back, the nerve rarely reaching the leaf-tip, and the leaves are usually slightly toothed in their upper part, and have plane margins; the capsule is round, and quite hidden among the upper leaves; the spores pale, roundish, smooth; leaf-cells large. In good fruit, March or April.

Ephemerum serratum occurs most abundantly in marly fields, but may also be found in sandy ones, and looks to the unassisted eye like a little patch of green conferva; the lens will, however, show the small reddish-brown sessile capsules, surrounded by the narrow lance-shaped, slightly toothed leaves; the leaves are nerveless, light-green, with transparent longish leaf-cells; spores yellow, globose, slightly roughened. In this moss the protonema (fig. 3, 1 *b*) continues throughout the lifetime of the moss; and hence, in a single specimen under the microscope, the life-history of a moss may often be seen—the protonema, young buds, perfect plant, and capsule bearing the spores. Fruit, October to April.

Archidium phascoides I have rarely found in fields, but it does occur occasionally in marly fallow fields; it is very minute, and requires close searching, and as the capsule is very small may often be passed over as a mere barren tuft of *Dicranella varia*. It may, however, be known by its round capsules and strongly nerved leaves, and by its giving off lateral, sterile, whip-shaped shoots from the fertile stem.

Pottia minutula I find not unfrequent in marly fields, in small, brownish-green tufts. The stem is very short, the leaves oblong, lance-shaped, tapering to the point, slightly overlapping and spreading when moist, erect when dry, margin much recurved; capsule on a short fruit-stalk; mouth naked, *i.e.* without a fringe; lid large, conical; leaf-cells quadrate.

Tortula unguiculata occurs in every sort of soil, is very variable, and often puzzling. Sometimes great glaucous green tufts of this moss will be seen without a vestige of fruit, at other times fruiting specimens will be abundant. The leaves are oblong, lance-shaped, blunt, with a minute point formed by the projecting nerve, margin curved towards the under side; leaf-cells dense and quadrate in the upper part, large and transparent below; leaves much twisted when dry; capsule erect, cylindrical; fringe of thirty-two twisted teeth; lid awl-shaped.

Funaria fascicularis occurs in sandy fields, in scattered tufts, and will be readily known by its widely lance-shaped toothed leaves, with large leaf-cells, pear-shaped capsule, convex lid, and inflated calyptra (fig. 20, 1), no peristome or fringe.

Many of our heath-lands are being rapidly reclaimed; and vexatious as it may be to the botanist to see the haunts of some of his favourites destroyed, he will, if wise, feel that it is far better that these lands should be made the means of employing labour and adding to the wealth of the country, rather than allowed to lie idle, the mere producers of weeds. But, in the neighbourhood of these reclaimed wastes, the borders of many of the fields, and the waysides of the lanes will still retain much of their heath-like character, and in such localities I have found the mosses of our heath-lands fairly represented. The mosses that I shall characterize as heath-mosses are *Ceratodon purpureus*, *Campylopus pyriformis*, *Bryum nutans*, *Funaria hygrometrica*, *Polytrichum piliferum*, *Hypnum cupressiforme*. These mosses, although abundant on heath-lands in Warwickshire, are by no means confined to such localities.

Ceratodon purpureus will be found abundantly on heathy waysides in good fruit about the middle of May, and will be found forming large dull-green patches, the purple fruit-stalk and fruit giving quite a character to the locality. The leaves are lance-shaped, with reflexed entire margins keeled on the back; the capsules oval, slightly curved, furrowed when dry, and slightly strumose at the base; lid conical, and fringe of sixteen teeth united by transverse bars. The

fringe of this species forms a beautiful object for the microscope.

Funaria hygrometrica will be found very abundantly in like places, more especially where the soil has been burnt, forming large yellowish-green patches, and when abundant has a very striking appearance (fig. 25). The leaves are large, very concave; the leaf-cells large, hexagonal; capsule curved, somewhat pear-shaped, purple, and furrowed when ripe, surmounted by a beautifully marked plane-convex lid; the peristome or fringe double, the outer fringe being formed

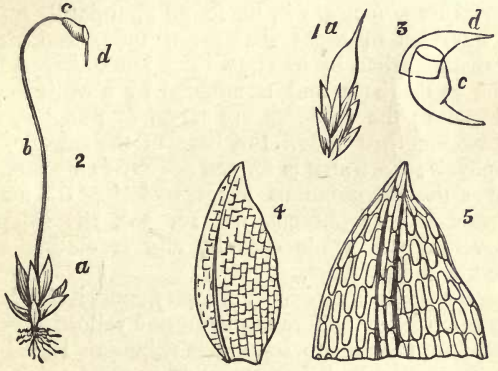

FIG. 25. *Funaria hygrometrica*. 1, young leafy plant; *a*, inflated calyptra. 2, nearly mature plant, natural size; *a*, leaves; *b*, seta, or fruit-stalk; *c*, capsule; *d*, calyptra. 3, capsule enlarged. 4, leaf enlarged. 5, tip of leaf × 140 diameters to show leaf cells.

of sixteen beautifully marked reddish teeth, the inner of sixteen yellowish teeth; annulus large.

Campylopus pyriformis, although abundant on our Sutton Park heath-lands, is by no means common on the heathy waysides; it will be found forming dense yellowish-green patches, the very fragile leaves being scattered abundantly over the patches; the leaves are lance-shaped, the nerve is broad, forming the greater part of the leaf, and composed of

small quadrate cells. The cells of the leaf-base are large and transparent. The fruit is rare, and is usually found in autumn.

Bryum nutans is a very abundant moss on damp heath-lands. I also find it in very dense masses on thatched roofs. It occurs in large dark-green tufts; the lower leaves are oval, lance-shaped, entire, the upper ones are longer, narrowly lance-shaped and toothed; the nerve scarcely reaches the tip of the leaf; leaf-cells hexagonal, elongated; fruit-stalk reddish; capsule pendulous, somewhat pear-shaped; lid convex, with a small point; fringe double. Fruit in May or June.

Polytrichum piliferum will be found abundantly on many heathy waysides in loose dark-green tufts, and may be readily distinguished by its large thick lance-shaped leaves, sheathing at the base, and terminated by a white hair-like toothed point; the capsules are large, four-angled, with a distinct swelling just below the base of the capsule, called the apophysis; the fringe is formed of sixty-four teeth, which curve over the membranous process closing the mouth of the capsule (the diaphragm, fig. 16, 3*a*), the calyptra is large, covering the whole capsule, and is clothed with a dense felt of shaggy hairs.

Hypnum cupressiforme occurs on every conceivable habitat, but may often be found forming extensive yellowish or dark-green patches, the foliage somewhat shining. In habit this moss is most variable, being sometimes prostrate, at others erect; but usually the stem is pinnate, the leaves curved to one side, more or less ovate, and suddenly drawn out to a toothed or entire point; the fruit-stalk arises from the side of the stem, and is surmounted by the curved capsule; the fringe is double, and the lid conical. Although this moss varies so much as to be fairly puzzling to the experienced bryologist, I find it may be always readily made out if a few of the leaves are taken from the stem and examined with the microscope. It will then be seen that they are either nerveless or faintly two-nerved, have very narrow elongate leaf-cells, *but the cells at the marginal base are quadrate and opaque.*

Dicranum spurium is a fine moss, growing on sandy heaths and also in woods; rarely, however, found in fructification. The stems are rigid, two to four inches long, with erect forked branches, all rising to nearly the same height. The lower leaves are egg-shaped or nearly so, the upper ones longer and much prolonged, and all more or less toothed on the margin in the upper part; the leaves are spreading when moist, erect and imbricated when dry, and have many minute papillæ on the lower surface.

Leucobryum glaucum will be found on damp heaths, growing in dense tufted masses. The stems are from two to

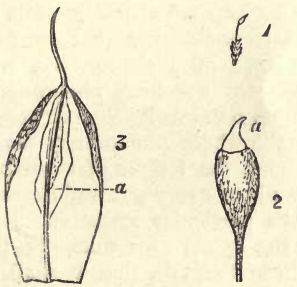

FIG. 26. *Pottia cavifolia.* 1, plant natural size. 2, capsule enlarged; *a*, beaked or rostrate lid. 3, leaf; *a*, lamellate or appendaged nerve.

four inches long; the leaves very spongy, glaucous, bibulous, and elastic. This moss will be readily recognised.

"Pleasant both to eye and mind, is an old garden wall, dark with age, grey with lichen, green with mosses of beautiful hues and fairy elegance of form," and on such habitats a great variety of species of moss will often be found; an old wall is the bryologist's botanic garden, where he may leisurely study his pet plants. A slight shower followed by bright sunshine, such a day as we often get in May, will often give him a pleasurable sight, such as he will long remember, for these alternations of wet and dry call into full play the peculiar properties of the annulus, and if he has only patience to watch and wait, he will see the little

lids of many of the capsules thrown off by a sort of magic force; and if the moss he is watching be a Bryum or a Hypnum, the outer fringe will be thrown back like the rays of a beautiful star-fish, the inner fringe all the while opening and closing, and the spores shot forth, by some hidden force within, a little cannonade of tiny balls, seeming as though the fairies were practising their minute artillery. Or, if continued dry weather has shrivelled up the mosses, so that they look more dead than alive, a slight shower will at once reanimate the shrivelled tufts, and he will see every moss, as it drinks in the grateful fluid, waken again into life, the shrivelled-up leaves once more assume their natural habit, the whole mass looks like a new growth, and the sudden resurrection calls to one's mind that wonderful desert plant *Anastatica*, the Rose of Jericho. But why direct one's attention to walls for watching phenomena that must be common to all moss habitats? Simply because a wall is so convenient, and the whole phenomena may be watched in such places without the fatigue of stooping. Stone walls, mud walls, and walls of every sort and degree, are all worthy of the bryologist's particular attention, and the older the walls the richer the spoils as a rule. So prolific, however, in mosses are these habitats, that I shall not be able to mention a tithe of what may be found by an industrious worker, and hence shall confine my remarks to a few of the more frequent species, such as *Tortula muralis*, *T. marginata*, *Grimmia apocarpa*, *G. pulvinata*, *Bryum capillare*, *B. cæspiticium*, *B. argenteum*, *Didymodon rubellus*, and *Pottia cavifolia*.

On mud-capped walls in calcareous districts, growing often in greatest profusion, *Pottia cavifolia* may be sometimes found; this is a small species, having large concave leaves, often terminated by a whitish hair-like point. If the leaves be examined with a lens, some peculiar membranous processes will be seen attached to the veins of the upper surface (fig. 26, 3 *a*). The capsule is egg-shaped, and the mouth has no fringe, or is naked, and the lid has a short inclined beak (fig. 26, 2 *a*). *Pottia truncata* (fig. 4), frequent on all sorts of walls and banks, has a wide-mouthed

capsule, and narrower leaves than the last-named variety, with no membranous processes on the upper surface.

Tortula muralis is one of our most frequent mosses, often filling up the interstices between the bricks of an old wall from its base to its top, growing in hoary, bluish-green tufts; the leaves are oblong with blunt tips, terminated by white hair-like points, very hoary in some of the varieties; the leaf-margin is recurved, leaf-cells minute and opaque in upper part, transparent and elongated below; the capsule is erect; lid shortly beaked; fringe of thirty-two teeth, beautifully twisted.

Tortula marginata is a more local species, partial to damp stone walls, and usually growing on the surface of the stone. At first sight not unlike the foregoing, but has narrower leaves, with the margin *thickened*, not recurved, and terminated by a minute green point. The fruit-stalk, too, is yellow in this species; reddish in *muralis*. Fruit characters similar to the last.

Grimmia apocarpa is a not unfrequent denizen of wall tops, forming deep-green loose tufts. The upper leaves are hair-pointed, with recurved margins. The capsules are sessile among the surrounding (perichætial) leaves. Lid slightly beaked; fringe of sixteen teeth, dark red, marked with transverse bars, and sometimes perforated.

Grimmia pulvinata is a very common species, growing on walls, and often in great masses on thatched roofs, forming round, hoary, cushion-like masses (fig. 19). The leaves are densely crowded, and suddenly terminated by long white-hair points. Fruit-stalk longish and bent downwards, so that the capsule is often hidden among the leaves. The lid has a straight beak; the teeth of the fringe sixteen, deep red and sometimes cloven at the tips. Calyptra mitriform, five lobed at the base.

Bryum capillare is very fond of old walls, and is very frequent; often occurs in large dense dark-green masses. The leaves are spreading when moist, but strongly twisted when dry, somewhat oblong and abruptly hair-pointed. Capsule somewhat pear-shaped, and pendulous; lid conical, with a minute point; fringe double; outer fringe reddish

brown, beautifully barred; inner fringe membranous, paler; spores small, green. The peristome of this common moss is a most beautiful object for the microscopist.

Bryum cæspiticium is also very frequent, growing in close compact tufts, of a yellowish or green colour. Usually very much like the last (fig. 1) at first sight; but in this the leaves are erect (not twisted) when dry, the lid yellow, not red as in *capillare*, and the spores minute and yellow.

Bryum argenteum may be readily known by its beautiful silvery foliage. The leaves are closely imbricated (overlapping); capsule pendulous, and passing abruptly into the fruit-stalk. Green forms, however, occur; but may at once be known by the closely imbricated leaves, with large cells.

Didymodon rubellus, so far as my own observations serve, is somewhat local; is usually fond of old shady walls; and fruits from November to February. Grows in dull-green tufts, which are reddish below; the leaves lance-shaped, somewhat clasping the stem at their base; margins recurved; leaf-cells minute in upper part, towards the base elongated and transparent. The leaves, too, are spreading when moist, but twisted when dry; the capsule is cylindrical; fringe of sixteen simple teeth; lid slightly curved and beaked.

A true bryologist should never be afraid of damp and dirty boots; if he be, I am afraid he will scarcely care to follow me to the habitats I have next to mention, that is, the marshes and bogs, and will thereby lose some of the rarest and most beautiful of the mosses. The odours of a marsh are not always of so grateful a nature as one would desire for a bouquet; but the gems which cluster round its margin, or more boldly brave its deeper depths, are worthy to be placed among the fairest of the floral world, and speak as loudly of the marvellous skill of the Great Designer, as the most beautiful and complicate of God's creatures. He who doubts this should examine with the microscope the wonderful structure of a Sphagnum leaf; and if the delicate network that he will then have revealed fail to charm, it will be because his power of appreciating beautiful objects is limited. Among other denizens of these watery situations

he will find the Sphagnums most abundant, and such mosses as *Bartramia fontana*, *Mnium subglobosum*, *Hypnum cuspidatum*, *Aulacomnion palustre*, and many other species, which space will not permit me to name.

Bartramia fontana is a frequent denizen of our Warwickshire marshes, but rarely in fruit (fig. 27). It occurs in more or less dense tufts of a glaucous green colour, and has the stems much matted together by reddish rootlets; the leaves are mostly ovate, with a prolonged point, have reflexed margins, and are slightly plicate at the base; the cells are small and quadrate; the leaf-margin bluntly toothed; the capsule is roundish, curved, marked with deep longitudinal furrows (fig. 27, 3), and reddish brown when ripe; fringe double; lid convex.

FIG. 27. *Bartramia* (*Philonotis*) *fontana*. 1, plant natural size. 2, dimidiate calyptra. 3, furrowed capsule.

Mnium subglobosum is a more local moss, but abundant in some marshes, occurring in dark-green tufts (fig. 28). The leaves are large, roundish, blunt, bordered with one or two series of elongated cells (fig. 28, 3 *a*), the principal portion of the leaf being formed of largish, roundish, hexagonal cells (fig. 28, 3 *b*); the capsules roundish, with a small, shortly beaked lid (fig. 28, 2 *a*); fringe similar to that of the Bryums.

Aulacomnion palustre is closely allied to the last, is fond of boggy or marshy places, and is usually abundant where it does occur; rarely, however, found in fruit. This species grows in large yellow tufts; the stems are coated by numerous reddish rootlets, and hence are much matted together; the leaves are crowded, spreading when moist, much twisted when dry, somewhat lance-shaped, roughened with minute projections on the surface, and toothed at the

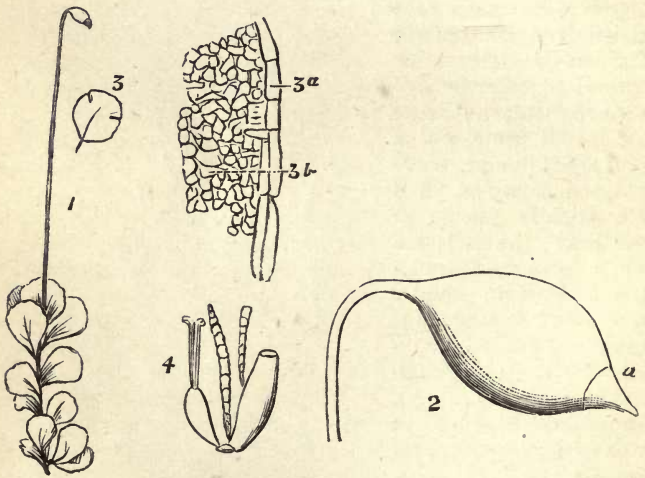

FIG. 28. *Mnium subglobosum.* 1, plant natural size. 2, capsule; *a*, conico-rostrate lid. 3, leaf; 3 *a*, marginal leaf-cells (border); 3 *b*, areolation. 4, synoicous inflorescence.

tips; leaf-cells roundish; the capsules are very rarely formed, but not unfrequently little green stalks are produced. which bear at their tips minute balls of gemmæ-like bodies, by which the plant is perpetuated (fig. 2, 2 *e*).

Hypnum cuspidatum is a very frequent inhabitant of marshes and other damp places, and usually fruits abundantly. This species grows in tall greenish or reddish-brown tufts; the stems are often four inches to six inches long

pinnately branched; branches remarkably cusp-like at the tips; leaves large, oblong, rather blunt, and nerveless; leaf-cells narrow and elongated; fruit-stalk lateral; capsule curved and turned to one side; fringe, consisting of an outer row of sixteen beautifully barred teeth, and an inner membrane of sixteen tooth-like processes; lid conical.

Many species of Sphagnum will be found in the bogs and marshes of the moor-lands, heath-lands, and damp woods; and, whilst I know of no mosses that are more difficult to determine, at the same time I know of none that surpass them in interest. The most widely diffused species are *Sphagnum cymbifolium*, *S. acutifolium*, varieties *ad lib.*, *S. contortum*, and *S. intermedium*.

FIG. 29. *Sphagnum cymbifolium*. *a*, capsule.

Sphagnum cymbifolium (fig. 29) is probably more readily made out than any other species, unless we take cognisance of some of those very near allies that have more recently been exalted to specific rank. This is one of the largest of our British species, having stems varying from one inch to a foot long. The branches occur in bundles of three, four, or five together, some of which are pendulous, and applied to the stem, and others are spreading. The leaves are closely imbricated, ovate and obtuse; but the most striking character is to be found in the cells coating the sides of the tumid branches—the utricles. These are elongated cells, and in this species are marked with numerous spiral lines. The fruit will be found from June to August, and the male flowers in the upper branches of the stem about March.

S. acutifolium (fig. 30) is readily known from the last species by its more slender stems, but runs into many varieties that are difficult to distinguish, except after much experience. The somewhat acute stem-leaves, five-toothed at the tip and broadly bordered, the utricles slightly recurved at the tip and wanting the spiral markings, and the

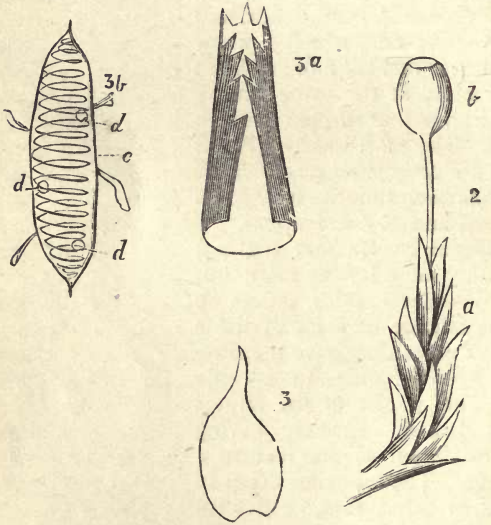

FIG. 30. *Sphagnum acutifolium*. 2, fruit enlarged; *a*, perichætial leaves; *b*, capsule. 3, branch-leaf enlarged; 3 *a*, apex of same highly magnified; 3 *b*, single cell from the middle of the leaf to show spiral fibres, *c*, and ducts, *d*.

branch-leaves acute, unchanged when dry, together with the slender habit of the plant, will be the best guides. This plant grows in dense tufts, and varies in colour more than perhaps any other species, being in some varieties a beautiful red, in others purple, and again pale green. Often found in abundant fruit about July or August.

S. contortum is more robust than the last, and is also

subject to much variation. Still, it may be known by the contorted branches, the large stem-leaves, strongly fibrose, by the leaf-cells being smaller than in the last and bordered round by numerous minute pores, and by the stem having only a single layer of cortical cells. Fruits July and August.

S. intermedium approaches *S. acutifolium* in its more slender habit; it grows in loose tufts, and is usually yellowish green. The stem-leaves are acute, but have neither the small pores nor fibres noticeable in many other species. The branch-leaves are acute and are somewhat undulated and recurved at the points when dry. The fruit is found about July or August.

The foregoing characters cannot be considered as more than vague guides by which to determine these plants, nor do I know of any simple guide to a knowledge of the species in this group; only frequent comparison and a constant use of the microscope will enable the student to properly understand that most protean group of mosses, the Sphagnums.

Possibly, the most restricted in their range are the Alpine mosses; for, whilst we may find many of the lowland mosses ascending to high elevations, there are other species that we should look for in vain, except either in high latitudes or on the summits of our loftiest mountains. These Alpine mosses will be found to vary considerably with regard to the species to be found in any given district, the nature of the rock, whether siliceous, calcareous, or granite, determining, in some manner, the character of the flora; possibly, the granite rocks have the more characteristic flora. To enumerate all the species of moss that are to be found in these elevated regions would be tedious. I shall therefore merely call attention to a few of the more special species, feeling assured that the student who seeks these will be so enamoured by the subject that he will scarcely neglect those not here mentioned.

Of Alpine species the following may be considered as representative; viz. *Andreæa nivalis*, *A. alpina*, *Dicranum Starkii*, *Grimmia ovata*, *G. atrata*, *Rhachomitrium patens*, *Amphoridium lapponicum*, *Oligotrichum hercynicum*, *Pogo-*

natum alpinum, *Conostomum boreale*, *Splachnum vasculosum*, and *Dissodon splachnoides*.

Probably the most adventurous and daring invader of Alpine heights among our British mosses is *Andreæa nivalis* (fig. 13, 3), a beautiful species growing in pale reddish-brown tufts, almost to the limit of perpetual snow, and plentiful on many of the mountains of the Cairngorm range. The stems are about two inches long, the leaves loosely imbricated, lance-shaped and slightly curved to one side, the nerve well defined and continued to the tip. Fruit terminal, at first oval; but as it becomes ripe it splits into four valves, which are held together by the lid, which in these mosses does not fall away, or is what is termed persistent. Fruiting in June or July.

A. alpina (fig. 13, 1) is more frequent than the last, being found in the elevated districts of England, Wales, Scotland, and Ireland. It differs from the last in the less-branched stems, leaves wider, more prolonged, and without nerves, and the widely gaping four-valved capsule. It grows in dense purple brown or almost black tufts, and has the leaves loosely imbricated when moist, closely pressed to the stem when dry. Fruiting in June or July.

Dicranum Starkii is found on the summits of some of the highest Scotch mountains and on Snowdon, growing in large yellowish-green tufts, which readily fall apart when gathered. The stem is branched; the leaves curved to one side, awl-shaped, prolonged, rigid when dry, with a strong, well-defined nerve; fruit-stalk terminal; capsule curved and swollen, with an enlargement at the base (strumose); lid beaked; peristome of sixteen forked teeth. Fruiting about August.

Grimmia ovata also occurs in elevated situations, growing in dark-green, somewhat hoary, compact tufts; leaves dark green, lance-shaped, and tapering to a point, which is terminated by a white-hair point, spreading when moist, erect when dry, and strongly nerved; fruit-stalk terminal; capsule oval; lid slightly beaked and grooved in the margin; peristome of sixteen perforated teeth. The fruit may be found from October to March.

G. atrata will be found on Scottish and Welsh mountains,

in dense blackish tufts; leaves almost black, except the uppermost ones, which are dark green; all are keeled on the back, rather blunt, nerved almost to the tips, margins turned down; fruit-stalks terminal; capsules erect, oblong; lid slightly beaked; calyptra split on one side; peristome of sixteen perforated or forked teeth. Fruiting from October to April.

Racomitrium patens is a more noble species, having stems two to four inches high, and growing in large, loose, green tufts, on moist rocks, in Scotland and Wales. The leaves are erect when dry, lance-shaped, pointed, and tipped with short hair-like points, keeled on the back, the keel being curiously two-winged; fruit-stalk on short terminal branches; capsule narrowly egg-shaped; lid conical beaked; peristome red; calyptra five-lobed at the base. Fruiting in summer.

Pogonatum alpinum (fig. 31) will be sure to attract notice, and may be known by its branched stems, about three inches long; leaves dark green, long, narrow, and toothed; capsule roundish, olive brown, slightly enlarged at the base; lid beaked; peristome of sixty-four pale teeth; and hairy calyptra. Fruiting in June.

FIG. 31. *Pogonatum alpinum*, 3, plant natural size.

Oligotrichum hercynicum is nearly related to the last, and is abundant on some of the Welsh and Scotch mountains, growing in short tufts about half an inch high. The leaves are dull green, thick, or fleshy, channelled, with a broad nerve, which is covered with curious rugose, wing-like processes; the leaves are incurved when dry; fruit-stalk terminal; capsule oblong, erect; lid conical; peristome of thirty-two teeth; calyptra split on one side, slightly hairy. Fruiting in July.

Amphoridium lapponicum may be found growing in the crevices of rocks near the summits of high mountains in Scotland and Wales, in loose dark-green tufts, about an inch high. The leaves are crowded, narrowly lance-shaped; nerve pellucid; fruit-stalk terminal, very short; capsule erect, dark brown, with eight furrows; lid shortly beaked. Fruiting in June or July.

Conostomum boreale has only been met with on Scotch mountains near the summits. The stems are about two inches high, and form dense green, level-topped, rigid tufts; leaves imbricated, pointed; fruit-stalk terminal, about one inch long; capsule slightly bending to one side and furrowed when ripe; lid conical curved; peristome red. Fruiting in July and August.

Splachnum vasculosum is one of the prizes that reward the daring Alpine climber, and must be looked for about the springs and streams of Scotch mountains, such as Ben Lawers. Stems unbranched and forming dense tufts; leaves large, pale, dusky green, roundish egg-shaped, concave, with a short nerve; leaf-cells large and transparent; capsule erect, cylindrical, with a large globular purple swelling at the base (*apophysis*), which is smooth when freshly gathered, but becomes corrugated when old or dry. Fruiting in summer.

Dissodon splachnoides is another of these prizes found in wet, turfy bogs on some of the Breadalbane range, growing in dense, blackish-green tufts. The stems are about an inch high; the leaves dark green, tongue-shaped, blunt, with a short nerve and large leaf-cells; capsules nearly erect, roundish egg-shaped, olive brown, with an apophysis more or less tapering into the fruit-stalk; lid convex, with a short point; peristome of sixteen short teeth. Fruiting about July.

The foregoing notes on moss habitats are, I am convinced, full of faults; they have, however, been given in the hope of calling the attention of some of the students of Nature to a vast and very beautiful family of plants, and, if they should induce any one to give some of his spare moments to this study, they will have served the purpose for which they were written.

IV.

CLASSIFICATION.

An essay like the present could scarcely be considered complete unless some account were given of the classification or systematic arrangement of the plants. It would be quite beyond the scope of this work to notice the various systems that have been from time to time adopted, and it would occupy too much space to go into the minuter details of the system here adopted, so that this will be merely a slight analysis of the larger groups, and it is hoped will be sufficient to give the student an intelligible idea of the affinities as well as the differences to be observed in these plants.

Mosses may be conveniently divided into groups by means of the situation of the fruit, its peculiarities, and the mode of branching of the stem. These main groups are three.

I. Acrocarpi. Fruit terminal (fig. 4).

II. Cladocarpi. Fruit terminal on short lateral branches (fig. 36).

III. Pleurocarpi. Fruit lateral (fig. 5), springing from the side of the stem.

The first group, Acrocarpi, has two sub-groups which many botanists place separately. This plan will be adopted here. These are :

Sub-group I. Schistocarpi.

Fruit splitting longitudinally into four or more valves, adhering at the top. *Andreæa* (fig. 13).

Sub-group II. Syncladei.

Branches fasciculate (*having clusters of short lateral unequal branches*). *Sphagnum* (fig. 29 and fig. 30).

Considering the two foregoing groups as forming separate series, the Acrocarpous mosses are divided into several

groups, called tribes, and these tribes are formed by genera having certain leading characters in common.

Sub-group III. Bryacæa.

SERIES I.—ACROCARPI. Fruit terminal (fig. 4).

Tribe I.—*Phascæ*. Plants minute; leaves soft; leaf-cells loose; capsules globose (fig. 14), more or less enclosed within the leaves; fruit-stalk usually very short; capsule splitting irregularly.

Comprising *Phascum*, *Ephemerum* (fig. 3), etc.

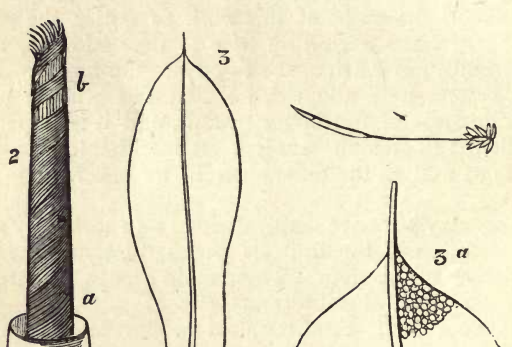

FIG. 32. *Barbula subulata*. 1, plant natural size. 2, upper portion of fruit: *a*, capsule; *b*, twisted peristome; 3, leaf enlarged; 3 *a*, cells of upper portion of leaf.

Tribe II.— *Weissiæ*. Plants tufted; leaves with a single nerve or vein; leaf-cells opaque, dot-like, or quadrate (*square*), often papillose (*with minute protuberances*) in the upper part, hexagonal and more or less transparent in the lower; lid usually beaked; peristome single or absent; calyptra split on one side.

This is a large group of mosses, including *Weissia*, *Dicranum*, *Ceratodon*, *Selegeria*, etc.

Tribe III.—*Pottiæ*. Branches fastigiate by innovations (*i.e. having additional branches of an equal height*); leaf-cells

parenchymatous, quadrate-hexagonal, papillose, and chlorophyllose above (*i.e. filled with green granules*), and transparent at the base; capsule erect, oval, or cylindrical; peristome of usually sixteen flat membranous teeth, sometimes simple and rudimentary, mostly split to the base into thirty-two thread-like, obscurely jointed segments; in some of the genera the peristome is absent.

This is an important tribe, comprising *Pottia*, *Trichostomum*, *Barbula* (fig. 32), etc.

Tribe IV.—*Grimmieæ.* Plants tufted, or growing in cushion-like masses; leaves short, solid, often tapering to a point, with hair-like tips; cells dense, obscure, dot-like, minutely round-quadrate, and filled with green granules above; capsule on a straight or curved fruit-stalk; teeth, sixteen, with transverse markings, cleft or pierced, rarely absent; calyptra generally lobed at the base, or split on one side (*dimidiate*).

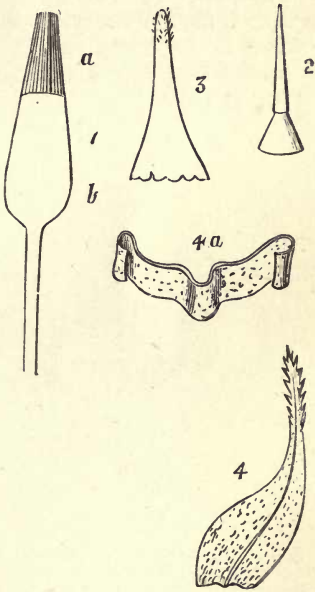

FIG. 33. *Racomitrium canescens.* 1, fruit; *a*, peristome; *b*, capsule. 2, subulate operculum or lid. 3, mitriforme calyptra, which is lobed at the base. 4, papillose leaf; 4 *a*, section of same to show revolute margins.

This comprises the genera *Grimmia* (fig. 19) and *Racomitrium* (fig. 33).

Tribe V.—*Orthotricheæ.* Plants tufted; leaves of close texture; calyptra lobed at the base, mostly plaited, often hairy; peristome of eight or sixteen flat, short, lance-shaped outer teeth, and eight or sixteen simple, thread-like inner teeth.

Comprising *Ptychomitrium*, *Orthotrichum* (fig. 34), *Encalypta* (fig. 11), etc.

Tribes VI., VII., VIII.—comprising *Tetraphidæ*, *Disceliæ*, and *Schistostegeæ*—are unimportant, and may be passed over.

Tribe IX.—*Splachneæ*. Plants and leaves of soft, loose texture; male flowers discoid; capsule with an apophysis varying in shape and size.

Embraces the genera *Dissodon*, *Tetraplodon*, and *Splachnum* (fig. 10).

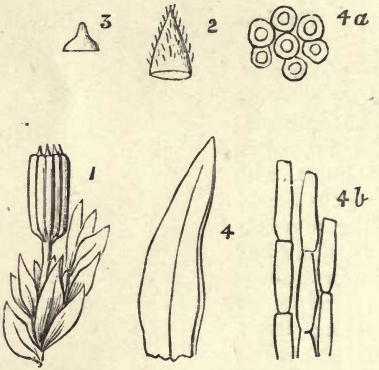

FIG. 34. *Orthotrichum stramineum*. 1, plant enlarged to show ribbed capsule. 2, hairy mitriforme calyptra. 3, conico-rostrate lid. 4, leaf enlarged; 4 *a*, upper leaf cells which are papillose; 4 *b*, elongated cells from base of leaf.

Tribe X.—*Physcomitrieæ*. Plants soft; leaves large; cells large and transparent; capsule rarely symmetrical, generally curved to one side and swollen; peristome absent or of sixteen teeth, inclined to the right, with an inner membrane divided into irregular segments, or rudimentary.

A group comprising *Physcomitrium*, *Entosthodon*, *Funaria* (fig. 25), etc.

Tribe XI.—*Bartramieæ*. Leaves papillose on both upper and lower surface; cells minute, quadrate in the upper part

of the leaves; capsule nearly spherical, turned to one side, ribbed when dry; peristome none, simple, or double.

Includes *Bartramia* (fig. 17), *Conostomum*, *Philonotis* (fig. 27).

Tribe XII.—*Meesieæ*. Leaves three to eight ranked; capsule with long fruit-stalk, and long-necked, turned to one side; peristome double; outer teeth much shorter than the sixteen segments of the keeled membrane, absent in *Catoscopium*.

A tribe of mosses nearly allied to the next following, includes *Catoscopium*, *Amblyodon*, *Meesia*, *Paludella*.

FIG. 35. *Mnium punctatum*. Natural size.

Tribe XIII.—*Byreæ*. Plants of various size; leaves simple nerved, generally toothed; leaf-cells prosenchymatous, equal, smooth; capsule globose, egg-shaped, or pear-shaped, turned to one side, horizontal or pendent, very rarely erect; peristome generally double; teeth transversely barred; inner membrane divided into segments alternating with the teeth, generally separated by cilia (*hair-like divisions of the inner peristome*).

A very natural group of beautiful mosses, often requiring very careful dissection and examination for their proper determination, including *Leptobryum*, *Webera*, *Bryum* (fig. 1), *Mnium* (figs. 21, 28, and 35).

Tribe XIV.—*Polytricheæ.* Plants woody; leaves thick, lamellate inside (*i.e. with longitudinal folds*); peristome simple, of thirty-two or sixty-four solid, tongue-shaped teeth, adhering to the membranous enlarged top of the columella (*the central portion of the capsule around which the spores are placed*).

This is a fine group of mosses, containing many noble-looking species, very distinct and easily recognised, includes *Polytrichum* (fig. 22), *Pogonatum* (fig. 31), *Oligotrichum*, and *Atrichum* (fig. 16).

Tribe XV.—*Buxbaumieæ.* Stemless plants with large oblique ventricose capsules; peristome double, the outer rudimentary, the inner membranous, twisted into a sixteen to thirty-two plicate or plaited truncate cone.

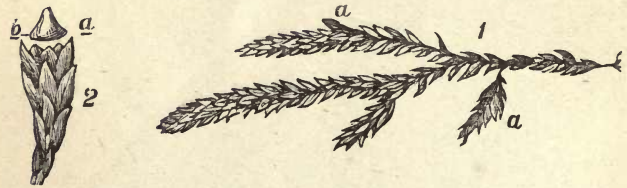

FIG. 36. *Fontinalis antipyretica.* 1, portion of plant natural size; *a a*, cladocarpous fruiting branch. 2, the same enlarged; *a*, lid; *b*, capsule.

A small group nearly related to the last, containing only the two genera *Diphiscium* and *Buxbaumia*.

SERIES II.—CLADOCARPI. Fruit terminal on short lateral branches (fig. 36).

Tribe XVI.—*Fontinaleæ.* Aquatic plants rooting at the base only, floating; leaves thin; flowers dicœcious; calyptra split on one side; teeth of the double peristome linear; inner membrane divided into long cilia forming a latticed cone by transverse partitions, or the cilia free, longer than the teeth, appendiculate.

A small group comprising *Fontinalis* and *Dichelyma*.

SERIES III.—PLEUROCARPI. Fruit lateral; flowers in axillary buds.

Tribe XVII.—*Neckereæ.* Primary stems creeping, the secondary erect or creeping with forked or pinnate branches; leaves smooth; cells minute; capsule generally enclosed in the perichætium (*the leaves immediately surrounding the base of the fruit-stalk*); calyptra split on one side, conical, often hairy; peristome simple or double, rarely absent.

To this family belong *Cryphæa*, *Neckera*, *Homalia*, etc.

Tribe XVIII.—*Leucodonteæ.* Primary stems creeping, the secondary erect or pendent, simple or ramose; leaves solid, subscarious, plaited lengthwise; leaf-cells in distinct rows, dot-like, angular; calyptra large, split on one side.

A tribe well represented in our flora, and comprising *Leucodon*, *Pterogonium*, *Antitrichia*, etc.

Tribe XIX.—*Hookerieæ.* Plants small, soft, sparingly and irregularly branched; leaf-cells large; calyptra conical-lobed at the base; peristome double.

A tribe of very distinct mosses, comprising the genera *Daltonia*, *Hookeria*, *Pterygophyllum*.

Tribe XX.—*Fabronieæ.* Plants very small; leaves thin, delicate, ciliate-dentate or entire; capsule pear-shaped, with a distinct collum, or neck; calyptra split on one side; peristome simple or none.

A small group, sparingly represented, comprising the genera *Habrodon* and *Myrinia*.

Tribe XXI.—*Leskeaceæ.* Primary stems creeping; leaves soft; cells minute, hexagonal, papillose, and chlorophyllose above, hexagonal-rectangular below; capsule symmetrical, erect or curved; peristome double; teeth linear-lance-shaped, awl-shaped, segments shorter than the teeth; cilia none or rudimentary, rarely perfect.

A group embracing several very widely spread mosses and others equally limited in their distribution, such as *Myurella*, *Leskea*, *Anomodon* (fig. 37), *Thuidium* (fig. 23), etc.

Tribe XXII.—*Orthothecieæ.* Plants in wide yellow mats; leaves smooth; leaf-cells narrowly rhomboidal or linear, square at the basal angles; capsule erect, symmetrical; peristome double.

In this group are placed *Pylaisia*, *Homalothecium*, *Climacium*, *Orthothecium*.

This group, although separated from the next, has many affinities with it, and would probably be united with it by most botanists.

Tribe XXIII.—*Hypneæ.* Plants of very variable habit; leaves of diverse forms, spreading or squarrose, rarely erect, often secund or falcate, with or without a central nerve, or two-nerved at the base, generally scarious, smooth, and glossy; leaf-cells prosenchymatous (fig. 5, 4 *a*), more or less narrowed, sometimes very narrow and vermicular (*worm-shaped*), quadrate and enlarged at the basal angles; vaginule attached to a perichætial, generally rooting branchlet; calyptra conical and cleft on one side; capsule with a long stalk, turned to one side (fig. 5), or horizontal, more or less incurved; peristome double (fig. 5, 3 *a b*), generally perfect, with two or three cilia appendiculate or articulate.

A tribe comprising the single genus Hypnum (fig. 5), but comprising more than 100 species, divided into about 21 sub-genera; many of these sub-genera are considered as genera by leading bryologists.

TABULAR ARRANGEMENT OF THE TRIBES AND SUB-TRIBES.

ACROCARPI.

Capsule globular immersed, splitting irregularly . . . . . *Phasceæ.*
Peristome none or simple, tissue of leaves dense . . . . . *Weissieæ.*
Peristome none . . . . . *Gymnostomum.*
Peristome simple, of 16 teeth . . . *Weissia.*
Teeth split to the middle; leaf-cells at base square, enlarged at the angles . . *Dicraneæ.*
Leaves distichous, conduplicate in the lower part; teeth split . . . *Fissidenteæ.*
Plants spongy, whitish yellow; leaves thick, composed of three layers . . . *Leucobryeæ.*
Leaves clasping at base; teeth 16, divided nearly to base into equal jointed segments . . . . . *Ceratodonteæ.*
Plants minute; capsule erect; teeth 16, single . . . . . *Seligerieæ.*
Capsule ovate; teeth 0 or 16; leaf-cells large . . . . . *Pottieæ.*
Teeth filiform, 32, distinct or in pairs . *Trichostomieæ.*
Capsule regular; fruit-stalk straight or curved; leaves often hair-tipped; cells dot-like . . . . . *Grimmieæ.*
Calyptra conical-lobed, hairy or smooth; cells dot-like; teeth 8 or 16 twin, inner teeth 8 or 16 thread-like . . *Orthotricheæ.*
Calyptra furrowed; teeth 16; leaf-cells dot-like . . . . . *Ptychomitrieæ.*
Calyptra large, funnel-shaped, persistent . *Encalyptieæ.*

Peristome composed of the cellular part of the lid; teeth 4 . . . . *Tetraphidieæ.*
Stems bud-like, annual; teeth 16, cloven at the base . . . . . *Discelieæ.*
Peristome none; leaves vertical, pinnate . *Schistostegieæ.*
Capsule apophysate; leaf-cells large . . *Splachneæ.*
Capsule irregular; calyptra inflated . . *Physcomitrieæ.*
Capsule spherical, ribbed when dry; leaves rigid, papillose; upper cells square . *Bartramieæ.*
Capsule long stalked; neck distinct; outer teeth short . . . . . *Meesieæ.*
Peristome double; leaf-cells large, equal, smooth . . . . . *Bryeæ.*
Leaves thick, rigid; top of columella enlarged; teeth 32 or 64 . . . *Polytricheæ.*
Stemless; capsule large, swollen; outer teeth rudimentary . . . . *Buxbaumieæ.*

Cladocarpi.

Aquatic, floating; fruit-stalk short; peristome double . . . . . *Fontinaleæ.*

Pleurocarpi.

Stem compressed, pinnate; fruit-stalk short or none . . . . . *Neckereæ.*
Leaves solid; leaf-cells dot-like; capsules erect . . . . . *Leucodonteæ.*
Stem flattened; leaves soft; cells large; calyptra conical-lobed . . . *Hookerieæ.*
Leaves imbricated; capsule pear-shaped with a distinct neck . . . . *Fabronieæ.*
Capsule symmetrical; leaf-cells minute, papillose . . . . . *Leskeaceæ.*
Leaf-cells narrowly rhomboid or linear, quadrate at the base; capsule erect . *Orthothecieæ.*
Peristome double; fruit-stalk long; calyptra cleft on one side . . . . *Hypneæ.*

The foregoing is necessarily a very condensed account of the classification of the mosses; but the student who desires to go more thoroughly into the matter must be referred to the very excellent "Cryptogamic Botany," by the Rev. M. J. Berkeley, pp. 470–507, where he will find the matter more fully dealt with.

V.

THE GEOGRAPHICAL DISTRIBUTION OF MOSSES.

Mosses will be found distributed all over the earth's surface, wherever the surroundings are suitable for the germination and development of their spores.

That this should be so is not astonishing when we consider how minute, light, and multitudinous these spores are—so minute that in many species a pocket lens is required to render them distinct, so light that every faint breeze carries on it myriads of these germs, so profusely produced that the contents of one capsule, if all germinated, would cover with verdure a large space of land, and any one species might, were circumstances favourable, diffuse itself over the earth's surface. But even with these plants, lowly organized as they are, taking their nutriment mostly from the surrounding atmosphere, and depending but slightly upon the soil for their well-being, even with these there is some sort of selection, so far as habitat is concerned, and a struggle for existence; and whilst some are cosmopolitan, others appear to be truly limited in their range.

Thus we find that some species, such as *Ceratodon purpureus*, *Racomitrium lanuginosum*, *Funaria hygrometrica*, *Hedwigia ciliata*, *Bryum argenteum*, *B. capillare*, *Hypnum cupressiforme*, are recorded in the floras and herbaria from all parts of the globe; whilst others, as *Voitia nivalis*, *Dawsonia superba*, *Hookeria læte-virens*, and others are equally restricted in their range.

Voitia nivalis, which is a fine moss, appears to be restricted to Europe.

Hookeria læte-virens, also a very noticeable species, is

restricted to Europe and Madeira; the genus is, however, represented in South America and New Zealand.

Dawsonia superba, a magnificent and remarkable species, is at present only recorded from New Zealand.

Many interesting facts will be revealed to us if we carefully compare the moss floras of contiguous and remote districts. Thus, comparing the moss flora of Great Britain with that of the Continent of Europe, we find that out of about 900 species recorded in Schimper's "Synopsis Muscorum Europæorum," Edition 2, we have 570 species recorded from the British Islands, and that there are about 325 species recorded from the Continent that have not as yet been found in these islands; whilst, on the other hand, notwithstanding the minute researches of our own bryologists, we have as yet only had about 16 species recorded from the British Islands that have not as yet been found on the Continent proper. But here it must be notified that some of these species are very minute, and may have been over-looked; whilst others are distinguished by minute differences that may not be considered sufficiently important to deserve specific distinction by foreign botanists. The most remarkable matter, however, is, that we have not only distinct species, but also distinct genera, as, for instance :—

Streptopogon gemmascens, "recorded from Surrey and not occurring on the Continent, but represented by seven species in the Andes, in the Himalayas, and three in the South Temperate zone."

Daltonia splachnoides, "recorded from Ireland, not found on the Continent, a genus having seventeen species in the Andes, two in Mexico, one in the Galapagos, six in India and Ceylon, five in Java, two in Africa, and three in the Antarctic Islands."

Hookeria, "which is a large genus of fine mosses, having representatives in the Andes, Brazil, Mexico, Pacific Islands, New Zealand, Java, India, Africa, Madeira, Cornwall, and Ireland, but in no part of Europe proper." *

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* "Island Life." A. Russell Wallace.

If we compare the moss flora of Europe with that of North America, or *vice versâ*, we shall meet with similar results. In Lesquereux and James's "Mosses of North America," we have about 900 species of moss recorded from that continent, and of these I find that about 515 species are natives of both the continents of Europe and America respectively, but 383 are non-European; whilst out of the 900 species recorded for Europe in Schimper's "Synopsis," 394 have not as yet been recorded from North America. A comparison of the European moss flora with that of India, shows, however, a great difference in the ratio of European species. In Mr. Mitten's valuable "Musci Indiæ Orientalis," about 770 species are recorded, and of these only 110 species are natives also of Europe. This record, however, can scarcely be a full one; and doubtless when that country has been more thoroughly investigated, the ratio of European species will be found to be greater.

But comparing the floras of still more distant countries, such as that of Europe with that of New Zealand, it will be found that the differences are more marked. Sir Joseph Hooker, in the "Handbook of the Flora of New Zealand," vol. ii., records 348 species as having been found in that island. Of these only sixty-six are recorded as natives also of Europe, and several of these being common species, liable to be introduced by man's agency, may be considered as doubtfully native. An analysis of Spruce's "Mosses of the Andes," yields nearly the same results.

But when we compare the moss flora of New Zealand with that of Tasmania, we find a great similarity in the record. Tasmania is very much more remote from New Zealand than England is from the continent of Europe, and yet of the 158 species recorded from Tasmania 120 species are natives of both that island and New Zealand. Many of these Tasmanian species will be found to have a wide range, some being found in South America, and at least twenty-seven are found in South Africa.

Berkeley, in the "Handbook of British Mosses," mentions a remarkable deviation from the general laws of distribution occurring in the centre of Germany: "In some situations

the great boulders which are scattered over the plains are the habitats of Alpine mosses, such as *Andreæa rupestris*, *Catoscopium nigritum*, *Grimmea leucophylla*, *G. tricophylla*, which can scarcely be considered as the natural mosses of such situations, but may probably be classed as remains, being possibly survivors of species borne from their native Alps upon these boulders during the glacial period." So that it will be seen from the foregoing that there are many anomalies in the geographical distribution of mosses, and that at present our knowledge is too limited to admit of a truly scientific exposition of the subject.

In the Introduction to the "Synopsis," chap. v., Prof. Schimper gives an interesting account of the geographical distribution of mosses in Europe. He divides the whole area of Europe into three zones.

1st. A northern zone, extending from the Arctic circle to the sixty-fourth parallel of latitude, embracing North Russia and the Scandinavian peninsula, and at its western end descending to 57°, so as to take in the north of Scotland.

2nd. A middle zone, embracing all the country between the 60th parallel of latitude, the German Ocean, and the south foot of the Alps, or a line on the forty-sixth parallel of latitude from the outlet of the Danube to the mouth of the Garonne.

3rd. A southern zone, extending south of the forty-sixth parallel of latitude to the Mediterranean and Black Sea. The northern zone presents sufficiently marked characters in the vegetation to indicate two divisions, which he calls the Arctic-northern and southern-northern zones. In the Arctic zone about 200 species are found; in the lower zone nearly 500 species, or about two-thirds of the whole European moss flora. But whilst the species in the Arctic zone are few in number, individually they are represented in such numbers as to give a characteristic feature to the landscape. The *Polytricha*, occurring in great masses, give quite a weird look to these inhospitable regions: here and there occur vast bogs covered with Sphagnums, and on the surrounding rocks black tufts of Andreæas and Grimmias. But here

some of the rarest species reward the more adventurous botanist; and it is in such unfrequented places in our own country, as amid the mountain districts of northern Scotland, that we may "hold converse with Nature, and view her stores unrolled." The lively green of more temperate climes is nowhere visible among the far and wide-spreading mosses of the Arctic northern region, yet among them are found scattered species which far excel those of milder climates in beauty, as *Splachnum luteum* and *S. rubrum*, *Bryum arcticum* and *Catoscopium*. As we proceed southward, new species are added to our list, the trees lose their lichens and often support mosses. Still the Sphagnum swamps are a noticeable feature. In addition to the species mentioned, we may also find *Splachnum Wormskjoldii*, *Encalypta procera*, *Mnium cinclidioides*, *M. hymenophyllum*, *Aulacomnion turgidum*, and quite a host of Hypna Brya, Andreæi and Dicrana, which are confined to the northern zone.

The middle zone, as it embraces the greatest extent of country and the most varied surface, is also richest in species; many of these pass over the northern and southern boundaries into the corresponding zones. More than 600 species have been recorded from this zone, and many of them characteristic of it, such as *Ephemerum tenerum*, *Ephemerella recurva*, *Anœcantgium Hornschuchianum*, *Tetrodontium repandum*, *Encalypta longicolla*, *E. apophysata*, etc.

The southern zone, having a more elevated temperature, and wanting the dense forests of Central Europe, is less adapted to the growth of mosses, and the list falls to 340 species. Yet the Pyrenees and Apennines have a rich moss flora, and some species are peculiar to the Mediterranean area, such as *Phascum carniolicum*, *Fissidens rivularis*, *F. grandifrons*, and a number of *Trichostomaceæ;* some of which creep up the Atlantic coast of France, and extend over the south of Ireland and south-west of England, and thus become rarities in the British flora, such as *Tortula Vahliana*, *Trichostomum flavo-virens*, *Bryum Tozeri*, and others.

Besides this superficial distribution, another still more

important is that of altitude or range above the sea level; this is marked out by lines or arches, extending from pole to pole, the crown or highest point being at the equator, and gradually descending northward, whilst at the Arctic zone they become approximated. Professor Schimper has described five zones of altitude, all of them characterized by certain predominant species.

Commencing at the sea level, we have—1st. The Campestral region, or that of cereal plants and fruit trees, which ascend the mountains to a varying height, according to the latitude. Thus, in the southern zone, in the Pyrenees, it reaches 3,100 feet on the south side, and 2,100 feet on the north side. In the middle zone it approaches 1,400 feet in the southern parts, falling to 750 feet and 500 feet in the northern limits. In the northern zone so rapidly from 500 feet to 0, that at 60° it disappears, and thus in the Arctic part of this zone the campestral region is wanting. This region in the separate zones presents different conditions of surface, such as the artificial substratum of elevated fields and roadsides, hills and woods, open desert plains, heaths, bogs, and marshes, and all varying *inter se*, according to the nature of the soil, whether calcareous or sandy, argillaceous or loamy, rocky or stony; and as each of these is more favoured by certain species, the aspects of the campestral region are very varying. In this region are found all those species which are diffused over the downs, heaths, woodlands, and hills of moderate elevations in the British Islands, a list too numerous to enumerate.

2nd. The Mountain region ascends from the region of cultivated plants to the upper limit of the beech, and extends in the southern zone from an altitude of 5,800 feet to 6,800 feet, in the middle zone from 1,400 feet to 3,400 feet, and in the Arctic northern descends into the plain very little above the sea level. The features of surface are dense woods of oak, beech, and pine, stony banks of streams and rocks, all localities congenial to a rich growth of mosses. The most characteristic species are *Bryum crudum*, *elongatum*, *Duvalii*, *Cinclidium stygium*, *Amphoridium Mougeottii*, *Racomitrium sudeticum*, *microcarpum*,

many *Dicraniaceæ*, *Grimmeaceæ Polytrichi*, *Ulota Drummondii*, *Ludwigii*, *crispa*, *Hypnum Halleri*, *crista-castrensis*, etc.

3rd. The Sub-Alpine region reaches from the limit of the beech to the upper limit of *Pinus abies*. The beech has ceased to be a tree where it does occur, and becomes a mere creeping bush. The chief features are pine and birch woods, rocky streams, bare mountain pastures, turfy bogs and rocks, the rapid streams bringing down many mosses of the next higher region, which mix with others from the one below. In the northern zone the most prominent mosses are *Andreæa rupestris*, *A. falcata*, *Campylopus Schwarzii*, *Blindia acuta*, *Trichostomum flexicaule*, *T. homomallum*, *Grimmia ovata*, *G. contorta*, *Racomitrium patens*, *Mnium cinclidioides*, *M. spinosum*, *Plagiothecium nitidum*, *Timmia*, *Splachnum*, *Pogonatum alpinum*, etc.

4th. The Alpine region extends from the limit of the fir, and commences with *Pinus pumilio*, or dwarf pine, ending where that ceases to grow. In the northern zone the birch tree has disappeared, but *Betula nana* or dwarf birch as an erect shrub occupies the marshy ground, and *Salix Myrsinites*, *Menziesia cærulea*, *Silene acaulis*, *Diapensia lapponica*, etc., flourish abundantly. Many fine mosses now appear for the first time, and yield a rich harvest to the collector. This flora, as represented in our North British districts, may be thus enumerated: *Dicranella Grevilleana*, *D. subulata*, *Dicranum falcatum*, *D. Blyttii*, *Stylostegium cæspitosum*, *Distichium capillaceum*, *Leptotrichium glaucescens*, *Grimmia funalis*, *G. atrata*, *G. alpestris*, *G. unicolor*, *Dissodon splachnoides*, *Webera polymorpha*, *Bryum julaceum*, *B. Muhlenbeckii*, *Polytrichum sexangulare*, *Hypnum sarmentosum*, *callichroum*, *Bambergeri*, etc.

5th. The Supra-Alpine region, reaching above the limit of *Pinus pumilio* and *Betula nana* to the line of perpetual snow. Here we have vast sterile rocks, some beaten and lashed by every tempest, others constantly irrigated by streams from melting glaciers, with patches of short grass, and black earth mixed with detritus from the rocks above.

In the middle zone this region lies between 6,800 feet and 8,300 feet; in the northern from 4,800 feet it descends gradually to below 2,800 feet. Although the line of perpetual snow does not touch our Scotch mountains, we have snow-fields more or less extensive lasting through the summer, as on Ben Nevis and the Cairngorm ranges; and we have some of the characteristic mosses, as *Conostomum*, *Bryum demissum*, *acuminatum*, *Ludwigii*, *Pottia latifolia*, *Dicranum fulvellum*, *Grimmia contorta*, *elongata*, and *montana*, *Andreæa nivalis*, *obovata*, *Hypnum glaciale*, *H. sarmentosum*, *arcticum*, etc.

VI.

CULTIVATION.

Possibly few have thought the cultivation of the mosses a matter worthy of their attention,—in fact, many a lover of plants would rather destroy than encourage them,—yet few plants more amply repay the little trouble they require. But the difficulty is to make a start, or, having made a start, to retain in a flourishing condition the mosses we have. The choicer species are often most difficult to manage, as though their untamed natures refused to submit to the thraldom of cultivation. Another difficulty that I have found is this, that the commoner species—such, for instance, as *Funaria*—will overrun all others, and become as it were quite masters of the situation. To attempt to raise these plants from spores is also another disappointment; certainly mosses come, but, so far as my own experience serves, not the mosses one requires. Hence I have found that, after all, the safest and surest way is to get the plants fully grown, to at once place them in their intended position, and above all to imitate as nearly as possible the natural surroundings of the plant.

Fern cases are sometimes recommended for this sort of culture; these I have tried myself, and have seen tried by others; and my own experience is, that whilst the mosses really look beautiful and all that one could wish for a while, yet after the first season they degenerate, many of them die out, and others are so drawn up by the glass as to destroy all their natural beauty.

The plan which appears to me to be the most successful is, as I have said, to get the plants from their native habitats in good condition, taking care to bring with them plenty of soil. I believe that one of the main reasons why these

plants will not thrive is, that the collectors neglect to do this.

The commoner species, such as *Funaria*, *Tortula muralis*, and *Ceratodon*, will scarcely require to be encouraged, as they will establish themselves wherever a likely wall or rock-work presents itself, providing that the place chosen is not in a smoky district. Some of the tree mosses, such as *Leucodon sciuroides* and *Anomodon viticulosum* (fig. 37), I have succeeded in growing by bringing some of the bark on which they were growing and fastening it down with pegs on the earth. To attempt to grow these after they have been removed from the bark will be sure to end in failure. In the case of those species which grow on rocks or stones, a

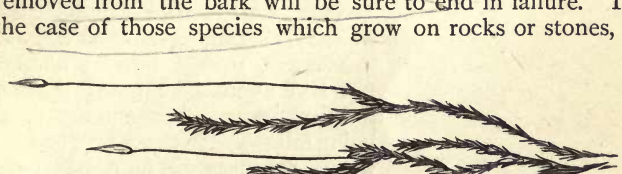

FIG. 37. *Anomodon viticulosum*, natural size.

portion of the rock should be, if possible, detached, as the mosses are more likely to live where they are established than they would be if they were removed from their habitat, and in these cases the pieces of rock, will require to be either bedded in the rockery or in pots, making the upper part of the rock level with or slightly above the level of the soil.

A very successful cultivator of mosses, Mr. R. Veitch, gives the following account of his mode of transplanting and cultivation: "For *Grimmia pulvinata* and *Orthotrichum anomalum*, I use a soft porous stone the size of the pot, filling it with drainage to such a height that the stone, when resting on it, is level with the brim. The patches are then placed upon the stone with a little space between each, and for the purpose of keeping them steady I sprinkle a

little fine mould into the open spaces. I then water them overhead with a fine rose. For mosses of this description little water is necessary; and it ought never to be applied until the leaves begin to collapse, and even then with a sparing hand. They should then be placed in a cool, shady situation, and in six or eight weeks they will be attached to the stones. The mould being first removed by means of a gentle run of water, the pots are then placed in a more airy and exposed situation." And speaking of a really more difficult class of mosses, he says: "All varieties which partake of the same trailing habit as *Hypnum prælongum*, should not be planted, but laid upon the mould; three or four small pegs will prevent them from being moved. In the course of a few weeks, the pegs will be covered with a mass of green foliage." My own plan has been to bring home a good mass of these plants with plenty of soil, to lay them upon the earth of the rockery, and pat them down well with a spade; this of course makes them dirty for a time, but a shower of rain soon remedies that. I have found that covering the newly transplanted mosses with peg lattice has been a great help against the attacks of small birds, who are very apt to ruthlessly root up these plants without some such protection.

FIG. 38. *Atrichum undulatum*, natural size.

Aquatic species, such as *Fontinalis antipyretica* or *Cinclidotus*, can only be grown in water, and in these cases I think it is imperative that a portion of the stone or wood to which they are attached should be removed with them. I have, however, grown *Fontinalis* for a season, well, without any attachment.

A few hints as to some of the more easily obtained and cultivated mosses may be of interest.

Atrichum undulatum (fig. 38) is a beautiful species, well worthy of attention; but it will require, during the winter, protection from frost or biting winds, and also plenty of moisture. Few species show so soon the influence of change of temperature. If a good supply of the beautiful fruit is required, it will be essential that good tufts are taken with a fair depth of soil, as the plant usually penetrates rather deeply, and care should be taken that there is a good sprinkling of the male flowers in the tuft. The soil used for potting this should be of a stiff marly or clayey nature, and little or no drainage will be required. A plentiful supply of water will be needed.

This plant will be found in woods and in moist, shady situations, more especially in heavy soils.

Pogonatum urnigerum (fig. 39) and *P. alpinum* (fig. 31) are both worthy of cultivation, and should have a good peaty

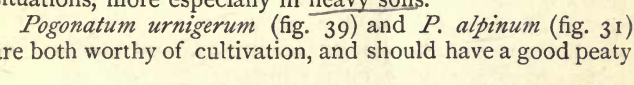

FIG. 39. *Pogonatum urnigerum*, natural size.

soil and plenty of root moisture. *P. commune* never seems to flourish more than one season, but might possibly be made to succeed if a good depth of soil were taken with it, and the plant were grown in a seed pan with plenty of silver sand mixed with the soil in which it was imbedded. This will also want a good supply of root moisture.

The extinguisher moss, *Encalypta vulgaris*, I have never grown. As this is an annual, it will require to be renewed year by year. But *Encalypta Streptocarpa* (fig. 11), which will be found often in abundance on old mortar-covered walls, will well repay cultivation. In this case I find it best to remove a fairly good patch of the moss with the mortar to which it is attached, and place it on the rock-work just as removed; and to keep it intact until I reached home, I have found it advisable to wrap the whole mass in some strong paper, else the friable nature of the mortar will cause it to crumble to pieces in the carriage.

Many of the *Bryums* are worth growing; and the large tufts of *Bryum capillare*, such as are frequent on old roofs, are easily removed and soon establish themselves, and if gathered when the fruit is still young and green will soon make a goodly show.

Mnium undulatum also thrives well if removed in good-sized tufts, and seems to thrive better than most species in the confinement of a fern shade. I have had it in beautiful fruit under such culture. *Mnium hornum* will require plenty of moisture, is easily cultivated, and will give a good supply of fruit.

The wall species, such as *Bryum argenteum*, *B. cæspiticium* (fig. 1), and *B. murale*, require but little moisture, and seem to thrive best when grown in shady situations. The genus *Hypnum* will yield a number of species that will amply repay any attention that may be given to them. My own experience will only embrace *H. rutabulum*, *H. prælongum*, *H. confertum*, and *H. denticulatum*. But I have seen *H. tamariscinum* and *H. loreum* cultivated in a friend's moss-house with great success, the former fruiting freely under culture, and the latter, although always sterile, still showing a most vigorous growth. *Hookeria lucens*, too, I have seen under like circumstances; and here the plan adopted was that of keeping the pot in which the plant was growing always immersed to a fair depth in water. The beauty of this plant when well grown can only be realized by those who have seen it.

Fissidens taxifolius (fig. 20, upper figure), which will be found on shady banks in heavy soils, may also be grown in a properly constituted soil; but with both this plant and the smaller species, *F. bryoides*, experience teaches that a fern case suits best for their growth. *F. adiantoides*, a fine moss growing in marshes, will do best with the treatment given to *Hookeria lucens*, as mentioned above; and as it always appears to fruit best in the dampest situations, such treatment would probably be productive of good results. I have never grown this. Many other species may be tried with success, such as *Aulacomnion palustre*, *Dicranum scoparium*, some of the *Rhacomitriums;* but experience will be a better teacher than I can hope to be.

VII.

USES.

LOOKING at these plants from a utilitarian point of view, it must be confessed that their uses are few—that is, if by use we mean only that which adds to man's material wealth, sustains him with nutritious food, or conduces in one way or other to his bodily comfort. But if we admit as of direct utility that pleasure, or source of pleasure and pleasurable instruction, that these plants afford to the naturalist, and that, too, at a season when few other plants offer themselves to his notice, then we may claim for these plants a right to be considered useful.

As is well observed by one of our botanists (Dr. Johnston): "It is curious to notice how gay these little mosses are on every wall-top during the winter months and in early spring, almost or perhaps the only things which seem to enjoy the clouds and storms of the season. They choose the most exposed situations, spread out their leaves, and push up their capsules amid rains, frost, and snow; and yet there is nothing in their tender, loose structure from which we could *a priori* infer their capability of resisting influences so generally destructive to vegetation. But so it is, the more simple the organization of plants, the stronger is their tenacity of life; and its phenomena are exhibited and called into play by stimulants, not only very feeble, but apparently the very reverse of those necessary to excite plants of a higher order. Thus mosses and lichens, overstimulated by heat and dryness, wither away in summer, but vegetate freely at a season when there is no other vegetation, and when their humble fronds cannot be overshadowed by a ranker growth." In highly civilized lands like our own, we are so abundantly provided with not only

the necessaries, but also the luxuries of life, that to us the uses of the mosses are few, and might by some be thought contemptible.

Hypnum triquetrum, from its extreme elasticity and lightness, is said to be much used for packing brittle wares, and is also sold in shops dyed often a most intense green for decorative purposes. *Hypnum purum* is used by anglers for the purpose of scouring worms. *Hypnum tamariscinum* is greatly employed for insuring the safe transport of leeches; they travel with far less injury when protected by the moss, than when in vessels of water only. *Fontinalis antipyretica* is employed in Sweden to fill up the spaces between the chimneys and the walls, and thus, by excluding the air, it prevents the action of the fire upon them. Hence it derived its specific name, *antipyretica*, which has led to the erroneous idea that it is incombustible. Johnston, in his "Flora of Berwick," says that, in the north of England, mattresses superior to those of straw are sometimes made with *Polytrichum commune*, and it is also woven into door mats, and its luxuriant stems are used for making neat brushes. White, in his interesting "Natural History of Selborne," Letter XXVI., says: "While on the subject of rural economy it may not be improper to mention a pretty little implement of housewifery that we have seen nowhere else; that is, little neat besoms which our foresters make from the stalks of the *Polytrichum commune*, or great golden maidenhair, which they call silk wood, and find in plenty in the bogs. When this moss is well combed and dressed and divested of its outer skin, it becomes of a beautiful bright chestnut colour, and being soft and pliant, is very proper for dusting of beds, curtains, carpets, hangings, etc. If these besoms were known to the brush-makers in town, it is probable they might come much into use for the purpose above mentioned."

To the Laplanders the services of this moss are much greater than to us, for it affords them both "bed and bedding." They choose the starry-headed plants, out of the tufts of which they cut a surface as large as they please for a bed or bolster, separating it from the earth beneath; and,

although the shoots are scarcely branched, they are nevertheless so entangled at the roots as not to be separable from each other. This mossy cushion is very soft and elastic, not growing hard by pressure, and if a similar portion of it be made to serve for a coverlet, nothing can be more warm and comfortable. "I have often," says Linnæus, "made use of it with admiration; and if any writers had published a description of the simple contrivance of the Laplanders (which necessity has taught), I could almost imagine that our counterpanes were but an imitation of it. They fold this bed together, tying it up in a coil that may be grasped by a man's arm, which, if necessary, they carry with them to the place where they mean to sleep the night following. If it becomes too dry and compressed, its former elasticity is restored by moisture." *P. commune* is slightly astringent, but is not now used here in medicine. In Germany it is esteemed as a sudorific. At one time it was famed for promoting the growth of hair, which it may probably do quite as well as some of our much-puffed nostrums.

Another useful tribe of mosses, the Sphagnums, may also be mentioned. These are now largely used in the cultivation of orchids, their power of retaining moisture rendering them of especial value to the gardener for this purpose. They have also been used for their package and transport in a fresh state. For this purpose they are excellently adapted, and Mr. W. Curtis obtained a reward from the Society of Arts for his valuable discovery of the great advantages derived from the use of these mosses for packing young trees for exportation. By Laplanders and Icelanders they are used for lining their neat and curious cradles. In cold countries they are also employed as a warm lining or stuffing for the loose deer-skin boots which the reindeer drivers wear. And lastly, to quote from Dr. Braithwaite's valuable work on the Sphagnaceæ: "As to the economic uses of the *Sphagnaceæ*, they are but small, except as a source of easily procured fuel, and in this respect indeed they are of immense importance, for no substitute could be found in the thinly populated and barren districts of the North, where trees become an insignificant object in the

scenery, or cease to grow at all; yet Nature, by the very means which produce these widely extended solitudes, supplies one of the first requirements of those who occupy them, and everywhere is peat annually cut, dried, and stored."

With regard to the functions of these plants in the formation of peat, I cannot do better than quote Professor Schimper's words. He says: "Unless there were peat-mosses, many a bare mountain ridge, many a high valley of the temperate zone, and large tracts of the northern plains, would present a uniform watery flat, instead of a covering of flowering plants or shady woods. For just as the Sphagna suck up the atmospheric moisture and convey it to the earth, do they also contribute to it by pumping up to the surface of the tufts formed by them, the standing water which was their cradle, diminish it by promoting evaporation, and finally also by their own detritus, and by that of the numerous other bog-plants to which they serve as support, remove it entirely, and thus bring about their own destruction. Then, as soon as the plant-detritus formed in this manner has elevated itself above the surface water, it is familiar to us by the name of peat, becomes material for fuel and all *Sphagnum* vegetation ceases."

But not only do mosses fill up and consolidate bogs, they are also as it were the pioneers of vegetation, and by their growth and decay year after year at length form a mass of vegetable mould sufficient for the nourishment of vegetables of higher organization; these in their turn give way to still higher forms, until at length we have, instead of a bare mountain side, a rich vegetation which may not serve merely to gratify our eye or inform our mind, but may also yield that which shall sustain us by its nutritive properties, or by its medical properties alleviate or mitigate our suffering.

VIII.

PREPARING SPECIMENS FOR THE CABINET AND HERBARIUM.

THE student who is in earnest about the study of the mosses will find a great advantage in having a series of well-authenticated specimens always ready for microscopical examination. As much time will be lost if these specimens have to be dissected whenever they are required for comparison (and this will often occur at starting), it is well to have as complete a series as opportunity will allow, permanently prepared for the microscope.

My own plan has been this: whenever I have received a specimen from an authority, or had my own specimen confirmed by authority, to at once mount a portion of this specimen, to label it with its proper scientific name, putting on the label the name of the moss, the authority, locality, and the number as given in the "London Catalogue of British Mosses." These moss slides I keep in a separate cabinet, placed in proper sequence, and each drawer in the cabinet has the first and last number of the species contained marked on the outside, so that I can at once find any slide I want. I have found this practice of greatest service.

To some of my readers it may be useful to give my own plan of preparing these specimens. I will therefore endeavour to give in a few words my own *modus operandi*. I may first state that I use the 3 × 1 inch glass slips, and the $\frac{5}{8}$ glass circles for my cover glasses. These can be obtained from most opticians at small cost. The moss to be mounted should first be well washed, to get rid of any dirt that may adhere to it; then, if recently gathered, soaked in tepid water; but if an old specimen, it will probably require to be boiled for a second in a test tube, to get rid of all air

contained in the leaf-cells, etc. This boiling does not injure the mosses, and will be always found necessary in such mosses as the Sphagnums. If the moss be a small one, such as one of the Phascums or a small Dicranella, it is well to mount the specimen whole, with all the various parts displayed, such as capsule, operculum, calyptra, etc. But it is always necessary to have one or two leaves carefully dissected away from the stems, so as to show their structure, the form and nature of the leaf-cells, the margination, *i.e.* entire or serrate on the margin, the shape of the base and the character of the cells at the base, a matter often of great importance. This may readily be done if the stem be cut through immediately below the base of the leaf, with a small knife or one of the triangular needles such as are used by glovers; the leaf should then be turned back and detached from the stem. In the Hypnums and other pleurocarpous mosses it is necessary to have perfect leaves from the stem as well as from the branches, as the character of the stem-leaves is always of importance in the diagnosis of the species. Some also of the perichætial leaves are also added, *these are the leaves immediately around the base of the fruit-stalk*, also the lower portion of the fruit-stalk divested of the perichætial leaves, to show the character of the vaginule. This is of special value in some mosses, as in the Orthotrichums. The capsule with the operculum on, and with it removed, may also be added, so as to show the presence or absence of the peristome and annulus, the character of the operculum or lid, whether conical, rostrate, etc. All these parts are then placed on a clean glass slip, and mounted in glycerine jelly, Deane's gelatine, or glycerine pure and simple.*

Before, however, mounting the specimen in either gly-

* It may here be mentioned that in some instances, *i.e.* where the leaf-cells of the moss are very dense, such as the Andreæas or the Grimmias, these cells may be made more distinct and their character more fully displayed if the leaves be placed for a short time in a heated solution of dilute liq. potass or liq. soda; but leaves so treated must be thoroughly washed afterwards in clean water, to remove all traces of the re-agent, before being mounted.

cerine jelly or Dean's gelatine, it should be soaked in a preparatory fluid, otherwise these mediums will not properly permeate the specimen. The preparatory fluid is made as follows :—

Rectified spirits, 1½ ounce.
Distilled water, 1½ ounce.
Glycerine, 3 fluid drachms.

Mix, and keep in readiness. A drop of this fluid is placed on the object, which may then be put away under a bell glass for one or two days. As the spirits and the water evaporate, the glycerine will take their places in the cellular tissue of the specimens. When pure glycerine is used, the specimens are better if soaked for a time in glycerine before being permanently mounted, so that all water contained in the object may be thoroughly displaced by the glycerine.

When the object has been well soaked in the preparatory fluid, it may then be mounted in either Deane's gelatine or glycerine jelly, the former medium being the best. All the superfluous fluid must be drained away, the glass slip and cover glass warmed. The gelatine may be melted by placing the bottle in which it is contained in a little hot water for a time. When melted, a drop should be placed on the object, the cover glass should then be gently breathed upon and carefully placed on the drop of the medium, and when this is thoroughly set, a ring of the white zinc cement should be put round the cover glass to fix it to the glass slip and also to prevent evaporation. The slide may then be labelled, numbered, and put away.

The peristomes of mosses also form beautiful as well as instructive objects. These should be mounted dry in most cases, although in some of the smaller capsules the whole capsule, with its peristome, may be mounted in one of the mediums above mentioned. My usual plan, however, is to mount these peristomes in a cell sufficiently deep to allow a cover glass to be affixed without injury to the object. The vulcanite rings serve, but are apt to warp, and so come off the slide later on. The glass cells are best, but are very

expensive; but some nice cells may be cut out of cardboard, as follows: "Two punches, similar to those used for cutting gun wads, are procured, of such sizes that with the smaller may be cut out the centre of the larger, leaving a ring whose side is not less than one-eighth of an inch wide. These rings may be readily made, the only difficulty being to keep the sides parallel, but a little care will make this easy enough. For these cells a close-grained cardboard with a well-glazed surface should be selected." The rings may be made to form a cell any depth by placing one upon another; and if they are well soaked in gold size, they will permanently adhere, and will be also rendered impervious to atmospheric moisture.*

The moss capsules to be mounted, assuming that several are going to be placed in the same cell, are all cut the same length, and fastened at the bottom of the cell with gum.† My own plan is to fix one capsule on the glass slip, at the bottom of the cell; and when this is firmly fixed, to build any other capsules I may wish to place in the cell around this. After allowing the gum to become quite dry, I then place on the top of the cell one of the round glass covers, and fasten this down with the white zinc varnish or gold size. It is often somewhat difficult to remove the operculums when the capsules are old and dry; but I have found that by placing these capsules in some hot water for a few hours, I could then readily remove the operculum with either one of the triangular needles mentioned before or with my dissecting knife. Of course, these capsules must be allowed to dry thoroughly before they are placed in the cell, and the spores should be removed from the inside of the capsule, else they will be found a constant trouble later on.

A good representative slide should have a capsule mounted with the operculum on to show its character; the

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* One of these cells, made as above, should be fixed to the glass slip with gold size, and allowed to become properly dried before being used; this will then form a neat cell.

† A mixture of equal parts of gum arabic and gum tragacanth is best as this makes an opaque fixing agent.

calyptra, and a capsule with the operculum removed to show the character of the peristome, when present; and all these parts should be so cut and mounted that they may be in focus with at least a two-inch objective.

Sections of the moss stems, leaves, and capsules will also be found very instructive objects. To get sections of the stems or leaves I take a fairly good quantity of the moss in question, and soak it in gum for a second or two; this, when dry, will fix the stems together in a bundle. This bundle I place in a section cutter, and with a sharp razor cut one or two very thin sections of the whole mass, floating the cuttings off on to one of the glass slips. In this way I get sections of both stems and leaves. The cuttings I examine with the microscope, and select out those which serve my purpose—or if there are none such among the cuttings, I make some more sections, until I get such as will suit my purpose.*

To cut sections of the capsule, I select a nice green capsule of such a moss, for instance, as *Funaria hygrometrica*, taking care that it is not too ripe for my purpose, though it is requisite that sections should be made through capsules in various degrees of development. These capsules I dip in gum solution, and allow to dry for a few minutes. I then fix them in a flat piece of the solid paraffine. This is readily done by making a shallow gutter in the paraffine with a heated wire or the tang of a small file. The capsules I place in this gutter, before the molten paraffine has set, placing it in as good a position for my purpose as possible. When the paraffine has set, thin sections are cut with a very sharp razor, cutting at the same time both paraffine and capsule, and these sections as cut are floated off into some water on one of the glass slips. The gum with which the capsules were coated soon melts, carrying with it the adhering particles of paraffine.

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* The water in which these sections are placed after cutting removes the gum used in fixing, and they may be more thoroughly washed by allowing a little water to trickle drop by drop among them; this will remove any superfluous particles of gum, etc.

The paraffine may then be removed with the needles or washed away, the sections examined with the microscope, and such as serve retained. Before mounting these sections permanently, they should be soaked for a time in a drop of the preparatory fluid above mentioned and then mounted in Deane's gelatine. Care will be required to be used in removing the sections from the slip on which they have been soaking to the mounting fluid, and I find the better way is to float them first of all on the slip I intend to use for mounting.

The sections of moss capsules I do not cut in a section cutter, but, placing the piece of paraffine in which they are fixed under a lens of about two-inch focal length, I cut the sections without the aid of either microtome or section cutter, merely watching through the lens so that I may see that I am not cutting my sections too thick. I have more than once cut nine sections out of one capsule in this manner. The razor will require constantly dipping in some fluid to get rid of adhering particles of paraffine, and I find that water with a slight addition of spirits of wine (methylated spirits will serve just as well) serves my purpose best. The razor used for this purpose cannot be too sharp, and should be kept with a nice clean cutting edge, to avoid any danger of fraying.

The section, when cut, should show well and distinctly capsule wall, alga-like cells in the air cavity continuous and complete, section of mother spore cell band, and the structure of the columella, as seen in fig. 9.

As a matter of course, every section will not be a success, —in fact, many of these will be worthless, but a little practice will soon render the cutting of these sections a matter of ease. The moss capsules that I have found most interesting are those of *Funaria hygrometrica*, *F. fascicularis*, *Bartramia pomiformis*, *Polytrichum formosum*,—this is a most beautiful object when well cut,—*Bryum capillare*, and *Tortula subulata* It must be distinctly borne in mind that the capsules must be fresh; if they cannot be cut immediately after gathering, they should be kept in water, so that they may be kept quite fresh; and, again, they must not be too ripe, otherwise the

spores will be formed, and in this state the section loses much of its beauty and interest.

To prepare mosses for the herbarium is a matter of little difficulty. First of all, they will require to be pressed, either between folds of proper botanical drying paper, or in some other absorbent paper; old newspaper will serve, but not so well as the botanical drying paper.

The pressure should be slight, not more than about 14 lbs. If the tufts are large, it is better to break them up into convenient-sized pieces, but not too much. The habit of the plant should always be shown, if possible. Where possible, it is of advantage to reserve a portion unpressed, *i.e.* simply allowing it to dry in the opened paper. Fragile or delicate species may be folded in thin cap paper, so that they may be removed from the drying papers without loss or hurt. And unless the specimens are very wet, three or four days' pressing will be enough, changing the drying papers each day.

When the specimens are dirty, as they often are in very wet weather, they may be washed by holding the specimen in the palm of the hand and allowing a stream of water to trickle on to them; they may then be dried with a rough cloth, and transferred to the press. It will be found advisable to remove any roots or leaves of grass, etc., from the tufts before they are pressed; it will be much more readily done when they are still fresh than afterwards.

When properly pressed, the specimens may be fixed upon sheets of note or other paper with gum, glue, or paste, or, better still, sewn on. The sheets should be of some fixed size, or some multiple of this. I find sheets of commercial note paper a very convenient size for large specimens, half sheets for smaller ones, and so on. It is also advisable to have specimens from more localities than one, and all the sheets of any one species should be fixed on one larger sheet. I use quarter sheets of double crown paper, 15 × 10, for pinning my smaller sheets upon; and I keep each species to a separate sheet, using a separate sheet for varieties. When the genus is a small one, I put all the species of a genus in a fold of thicker paper, stout cartridge or brown paper; and

where the genus is a large one, I have two or more such folios, putting the name of the genus at the top of the sheet, with the first and last number of the species in the folio on the margin. For instance, if the folio contained the genus Dicranella, I should head the sheet with that name, and on the margin put 48—57, these being the numbers as given in the "London Catalogue of Mosses." The generic and specific name of each moss should be placed on the sheet on which it is mounted, together with the locality and date when collected. It will be found serviceable, when a specimen is examined microscopically, to sketch what is seen on the paper to which it is fastened. This will often render the sheets of great value and assistance in future investigations.

I have found that a magnifying power of 70 diameters is sufficient for nearly all the mosses that I have determined; or when some more critical point had to be decided upon, 140 diameters.

"The tiny moss, whose silken verdure clothes
The time-worn rock, and whose bright capsules rise
Like fairy urns on stalks of golden sheen,
Demands our admiration and our praise,
As much as cedar kissing the blue sky,
Or Krubal's giant flower. God made them all,
And what He deigns to make should ne'er be deemed
Unworthy of our study and our love."

Butler & Tanner, The Selwood Printing Works, Frome, and London.